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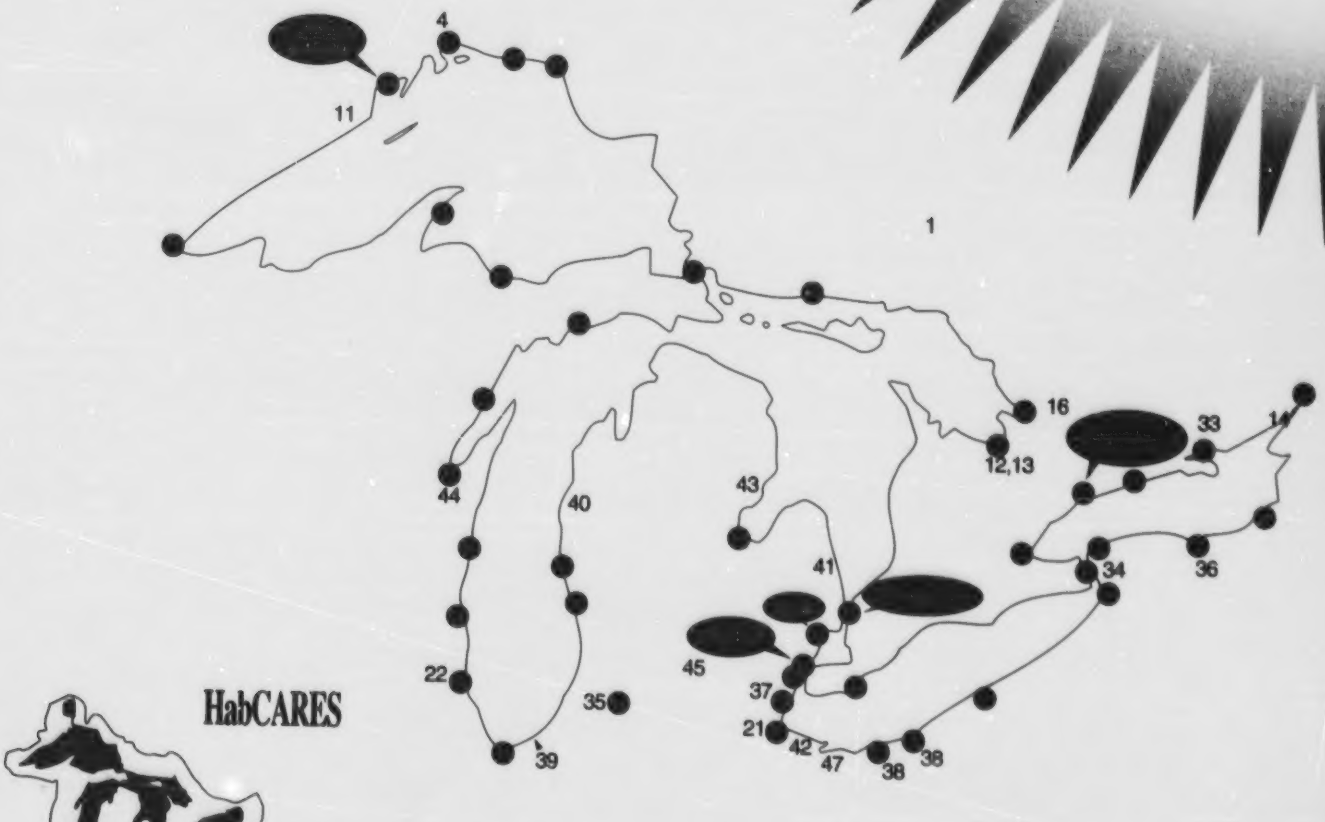
Methods of Modifying Habitat to Benefit the Great Lakes Ecosystem

J.R.M. Kelso • J.H. Hartig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HabCARES
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Methods of Modifying Habitat to Benefit the Great Lakes Ecosystem

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Abstract

The governments of Canada and the United States recognized that their boundary waters cannot be restored and enhanced independently without the use of an ecosystem approach. The actions needed to prevent ecosystem perturbation and to restore, protect, and conserve ecosystem integrity in the Great Lakes basin are the result, primarily, of response to the Great Lakes Water Quality Agreement as amended in 1987, the Great Lakes Fisheries Convention and agreements and memoranda of intent among governments. The array of techniques to restore, rehabilitate, and enhance ecosystems must be assembled as an early step in developing action plans to respond to law, policies, and programs.

This compilation of 47 methods of modifying habitat to benefit the Great Lakes ecosystem provides a foundation for selecting and evaluating habitat rehabilitation and conservation actions. These methods reflect the diversity in habitat modification and conservation techniques in use in the Great Lakes basin; however, not all projects underway in the basin are included. A process framework is provided to help select methods of modifying habitat. All descriptions made available to us 1 February, 1995, are included and are presented in no particular order.

Fifty-five percent of the projects describing habitat modification have not been completed, implemented or assessed. Consequently, it is important to monitor the process of selecting methods for restoring and enhancing ecosystems, and to assess the progress toward goals and quantitative end points on an ongoing basis. Seventy-seven percent of the methods described in this manual are the result of initiatives at Great Lakes Areas of Concern. However, ecosystem based objectives for the Great Lakes also are provided by the Joint Strategic Plan for Management of Great Lakes Fisheries and lakewide management plans (LAMPS). These 47 methods demonstrate binational progress toward ecosystem objectives and provide prototypes of actions for further progress.

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Résumé

Les gouvernements canadien et américain reconnaissent qu'il est impossible de restaurer et de revigorer leurs eaux limitrophes sans tenir compte de l'écosystème dans son ensemble. Les mesures nécessaires à la prévention de la perturbation de l'écosystème ainsi qu'à la restauration, à la protection et à la conservation de l'intégrité de l'écosystème dans les Grands Lacs sont principalement les conséquences de l'Accord relatif à la qualité de l'eau dans les Grands Lacs (modifié en 1987), de la Convention sur les pêcheries dans les Grands Lacs et des ententes et mémorandums déclaratifs d'intention des gouvernements. Lorsqu'on entreprend l'élaboration de plans d'action qui sauront répondre aux lois, politiques et programmes, il est crucial de faire le bilan, en premier lieu, de la multitude de techniques existantes de restauration, de réhabilitation et de reconstitution des écosystèmes.

Le présent recueil de 47 méthodes de modification de l'habitat pour la reconstitution de l'écosystème des Grands Lacs forme un excellent point de départ pour la sélection et l'évaluation des mesures probantes de restauration et de conservation de l'habitat. Il reflète la diversité des techniques de modification et de conservation de l'habitat en pratique aux Grands Lacs sans toutefois toutes les représenter. On y trouvera en outre un cadre de processus qui facilitera la sélection des méthodes les plus appropriées de modification de l'habitat. Toutes les descriptions desquelles nous disposions le 1er février 1995 y sont recensées, sans ordre particulier.

Cinquante-cinq pour cent des projets qui portent sur la modification de l'habitat n'ont pas été achevés, mis en œuvre ou évalués. Par conséquent, il est important de suivre de près le processus de sélection des méthodes de restauration et de reconstitution des écosystèmes et d'évaluer périodiquement le progrès à la lumière d'objectifs et de cibles quantitatives. Soixante-dix-sept pour cent des méthodes décrites dans le présent manuel sont le résultat de projets au *Great Lakes Areas of Concern*. Toutefois, les objectifs d'écosystème des Grands Lacs proviennent aussi du *Joint Strategic Plan for Management of Great Lakes Fisheries* et du Plan d'aménagement panlacustre (LAMPS). Ces 47 méthodes illustrent le fruit des efforts concertés américo-canadiens en matière de protection de l'écosystème et offrent des prototypes de projets pour poursuivre cette évolution.

Preface

The Government of Canada and the Government of the United States of America recognized that restoration and enhancement of their boundary waters can not be achieved independent of other parts of the Great Lakes Basin Ecosystem. To achieve a healthy basin ecosystem, the Great Lakes Fishery Commission (GLFC) set "achievement of net gains in the quality of aquatic habitats" as one of five major milestones for the ecosystem. Similarly, United States and Canadian aquatic resource agencies identified degradation and loss of habitat as impairing the integrity of the Great Lakes Basin Ecosystem and called for improvements in habitat rehabilitation and conservation.

This compilation of 47 methods of modifying habitat to benefit the Great Lakes ecosystem provides a foundation for selecting and evaluating habitat rehabilitation and conservation methods. A workshop on the science and management for habitat conservation and restoration strategies in the Great Lakes basin (HabCARES 1994) provided contacts and the framework for describing methods of beneficially modifying habitat. The workshop was jointly sponsored by Canada's Great Lakes 2000 Cleanup Fund, the Habitat Advisory Board of the GLFC, the U.S. Environmental Portection Agency, the Canadian Department of Fisheries and Oceans, the U.S. Fish and Wildlife Service, the Ontario Ministry of Natural Resources and Environment Canada. The Habitat Advisory Board views this document as a first edition, looks forward to future editions, and seeks to apply the experiences from these reported initiatives in its role of addressing protection, rehabilitation, and enhancement of fish habitat.

All descriptions of habitat modification initiatives made available to us 1 February 1995, are included and presented in no particular order. The 47 descriptions reasonably reflect the diversity in habitat modification and conservation in the Great Lakes basin; however, not all projects underway in the basin are described in this manual. No project descriptions were excluded so that all might benefit from the experience of the proponents.

Introduction and Overview

Actions to restore, protect, conserve, and prevent ecosystem perturbation in the Great Lakes basin are the result, primarily, of response to the Great Lakes Water Quality Agreement as amended by the 1987 Protocol, the Great Lakes Fisheries Convention, and memoranda of intent among governments. The responsibility for action from these acts and agreements is shared among all sectors of society. Objectives set in response to agreements such as those above provide both broad and specific desired future results of management actions (White 1991).

Purpose is provided by objectives. End points or targets identify quantifiable conditions that signal success and progress toward achieving objectives. Through Annex 1 of the 1987 Protocol to the Great Lakes Water Quality Agreement, the Canadian and United States federal governments, in cooperation with the state and provincial governments, agreed to develop lake-specific ecosystem objectives to maintain and restore physical, chemical, and biological integrity. Ecosystem objectives currently exist for Lake Superior (Lake Superior Work Group, November 1993) and are in different stages of development for the other Great Lakes made under the Joint Strategic Plan for Management of Great Lakes Fisheries. Fish community objectives and implied environmental objectives have been developed for Lakes Superior and Erie (Busiahn 1990; Koonce 1994) and a process has been developed and is being applied to ensure compatibility and integration among objectives (Hartig 1993; Koonce 1994). The evolved, cooperative process in the Great Lakes basin ecosystem provides some assurance that the focus is upon objectives, upon the needs which are defined to direct management actions, upon results, and thus the tendency to focus upon techniques is avoided.

However, once objectives and end points have been developed and the appropriate degree of consensus achieved, a suite of ecosystem management options which can provide progress to end points are available. Restoration, rehabilitation, conservation, mitigation, and protection of habitat are among the array of management options. Integration of management actions for habitat with other environmental and resource management options is ultimately required. Accumulating the array of techniques for habitat restoration and rehabilitation is an early step required in the development of action plans centering around habitat. This manual of methods for modifying habitat to benefit aquatic ecosystems provides a partial array of habitat alterations which can contribute to restoration objectives in the Great Lakes.

Intent

This resource document summarizes a range of available (1 February 1995) methods for rehabilitating, restoring, enhancing, mitigating, or preserving habitat in the Great Lakes basin ecosystem. The information on habitat modification methods is intended to make individuals and organizations aware of the range of habitat rehabilitation and conservation techniques in use, provide summary information about projects to aid the methods selection process of future initiatives, and provide contact persons for follow-up. In addition, this document is intended to promote consistent and thoughtful application of habitat rehabilitation and conservation methods throughout the Great Lakes basin. However, we emphasize that the selection and use of habitat "tools" must be done through objectives setting, end point definition, and an option selection process.

The intended audience for this manual of "methods" includes: managers of fish and wildlife programs; fishery and wildlife biologists from resource management agencies; lakewide management plan (LAMP) coordinators; remedial action plan (RAP) coordinators; public interest groups and non-governmental organizations; conservation authorities and watershed councils; municipal planners; consultants and engineers.

Each description of habitat modification methods is concise in order to present an overview of the diversity of habitat projects. Each description of habitat methods follows a standard format, i.e., Title, Contacts, Agencies Involved, Goal, Project Type, Background and Rationale, Regulatory Considerations, Criteria, Project Design, Implementation, Degree of Environmental Intervention, Cost, Biological Assessment, Measures of Success, and Key Referenc[illegible] Each habitat project is rated according to the following system: (1) assessment incomplete, (2) [illegible]ion was deleterious, (3) no change or inconclusive, (4) successful, or (5) exceeded goals. Success is rated by the proponent of the habitat modification initiative. A successful project may be simply one where construction is complete. Each description of habitat modification methods includes addresses and telephone, fax, and E-mail numbers of contact persons to encourage interaction of persons interested in rehabilitating and restoring habitat with those having practical experience.

It is important to clarify what this document will not do. This manual does not provide:

- guidance on action plan development;
- a step-by-step or cookbook approach to developing a habitat rehabilitation and conservation strategy;
- guidance on objectives setting, end point definition, or option selection processes;
- methods for habitat classification or inventory;
- accepted protocols and methodologies for determining success or "value" of the habitat modification method; or
- methodologies for cost-benefit analyses.

Scope

The term ecosystem is broadly applied herein. Modifications to habitat will affect ecosystems; however, the methods described may have been developed and used solely in aid of fisheries management. Therefore, the contribution of a habitat modification to the ecosystem is probably understated. This manual assumes that habitat modification is required for one of the following three reasons:

- to achieve ecosystem-based objectives established within the Great Lakes institutional framework, e.g., habitat modification will lead to progress toward specified, ecosystem-based end points made under the Joint Strategic Plan for Management of Great Lakes Fisheries, LAMPS;
- to restore lost or damaged habitat as called for in Annex 2 of the 1987 Protocol to the Great Lakes Water Quality Agreement, Canadian Fisheries Act, etc.; or
- to rehabilitate habitat or mitigate the effects of habitat degradation in order to improve or enhance ecosystem structure or function.

Recognition of the need for habitat rehabilitation and conservation has been increasing, particularly over the past decade. For example, Table 1 presents the change in the number of Great Lakes Areas of Concern which identified degraded fish and wildlife populations and loss of fish and wildlife habitat as use impairments between 1989 and 1994. In fact, 77% of the methods described in this manual are the result of initiatives at Great Lakes Areas of Concern (see Figure 1). There was a 50% increase in the number of Areas of Concern that acknowledged loss of habitat between 1989 and 1994. Similar trends in increasing recognition of the need to rehabilitate and conserve habitat are evident in Great Lakes LAMPs and in the committees established under the auspices of the Great Lakes Fishery Commission to develop fish community objectives called for in the Joint Strategic Plan for Management of Great Lakes Fisheries.

Table 1. Status of degradation of fish populations and loss of fish habitat in Great Lakes Areas of Concern (1989, 1991, 1994).

Year	Total Number of Areas of Concern of Fish Populations	Number of Areas of Concern Which Acknowledged Degradation of Fish Habitat	Number of Areas of Concern Which Acknowledged Loss
1989[a]	42	16 (38%)	17 (40%)
1991[b]	43	24 (56%)	24 (56%)
1994[c]	43	29 (67%)	34 (79%)

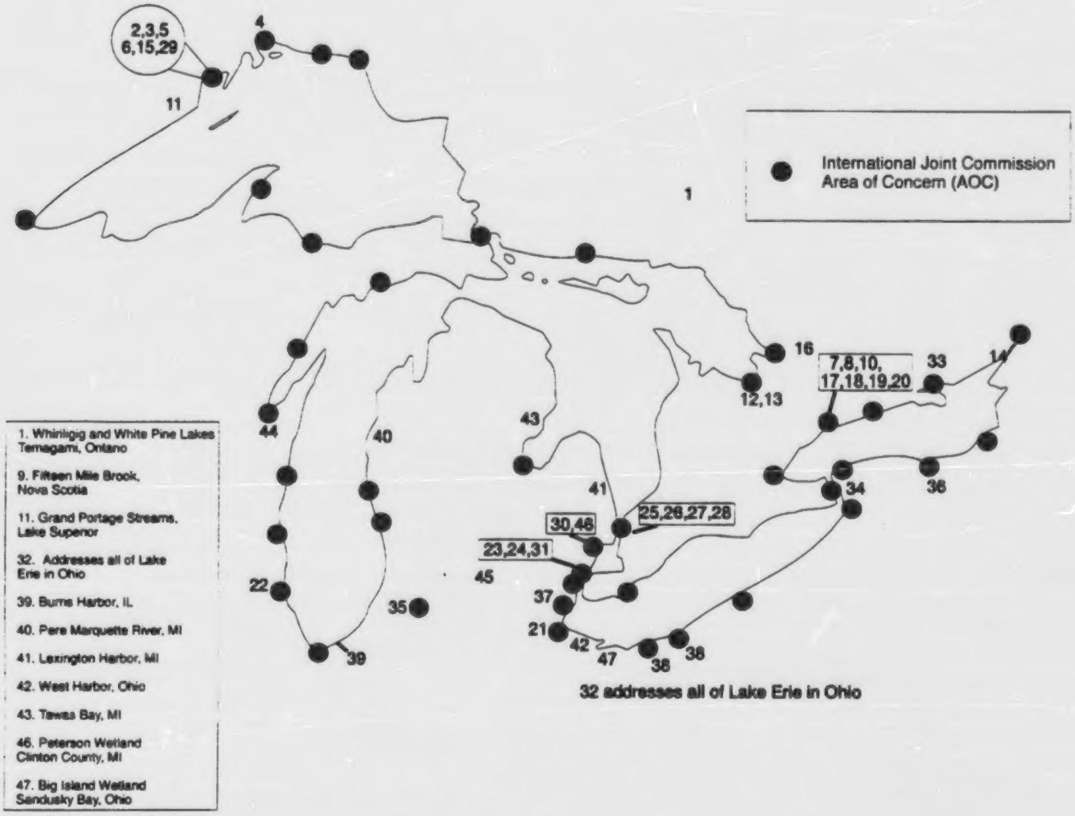
[a] IJC (1989); [b] IJC (1991); [c] Hartig and Law (1994).

In response to the increased focus on habitat, this manual was assembled to aid implementation of remedial and preventive actions. It may be important to distinguish among restoration, remediation, and modification (Table 2) to understand the basis for habitat modification. The goal or need which initiated the habitat modification is provided, but the method should not be viewed as appropriate only to the stated goal.

Table 2. The differences among restoration, remediation, and modification pertaining to the use of this manual.

Term	Definition
Restoration	Management to return a damaged ecosystem to its predisturbance condition (Cairns 1993)
Remediation	Rectifying or making good (The Concise Oxford Dictionary); reclamation, enhancement, or rehabilitation imply putting an ecosystem into new, altered, presumably better use (Cairns 1993)
Modification	Change in state; in the case of this manual, habitat modification assumes that change results in an improvement in condition of ecosystems

The descriptions of methods to modify habitat presented in this manual reflect the array of habitat restoration and rehabilitation projects in the Great Lakes basin (1 February 1995). Locations of habitat modification projects are presented in Figure 1. The array of technologies which might be applicable to actions in the Great Lakes basin is, however, incomplete. Design and construction are detailed generally. Measurements used to assess success are provided, but more and better assessment will benefit future users of similar methods. Additional methods will be developed as programs in the Great Lakes basin shift from problem definition to action; therefore, this manual is formatted to accommodate iterations as present methods for habitat modification are applied and evaluated, and new approaches are developed.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32 addresses all of Lake Erie in Ohio
1. Whirligig and White Pine Lakes Temagami, Ontario
9. Fifteen Mile Brook, Nova Scotia
11. Grand Portage Streams, Lake Superior
32. Addresses all of Lake Erie in Ohio
39. Burns Harbor, IL
40. Pere Marquette River, MI
41. Lexington Harbor, MI
42. West Harbor, Ohio
43. Tawas Bay, MI
46. Peterson Wetland Clinton County, MI
47. Big Island Wetland Sandusky Bay, Ohio

Figure 1.

Tools of Ecosystem Remediation

Methods for ecosystem remediation may be grouped into functional management classes of action (Table 3) relating to:

1) modifications to flow or water quantity;
2) water quality management;
3) habitat management;
4) biological intervention in aquatic or terrestrial environments; or
5) controls on human activities.

Methods for modifying or manipulating habitat were sought by a request to cooperators in the 43 Great Lakes Areas of Concern, members of the Habitat Advisory Board of the Great Lakes Fishery Commission, Environment Canada, U.S. Environmental Protection Agency, Ontario Ministry of Natural Resources, resource management agencies in the eight Great Lakes states, U.S. Fish and Wildlife Service, U.S. Army Corps of Engineers, the U.S. National Biological Service and Canada's Great Lakes 2000 Cleanup Fund which provides resources to cooperating groups at Canadian Areas of Concern, the Canada Department of Fisheries and Oceans, and participants at the November 1994 HabCARES Workshop. All submitted project descriptions are included, although some may provide greater benefit to water quality, may affect flow or water quantity, may involve biological manipulation, or may affect human activity in the watershed.

Table 4 summarizes the status and what is known of the effectiveness of the habitat modification methods presented in this manual. Of the 47 projects, 12 are in initial stages of implementation and have an assessment component planned, 13 have been implemented yet post-project monitoring is insufficient to quantify change in ecosystem structure and function, and 20 have been implemented and post-project monitoring has quantified in some way change in ecosystem structure and function.

Based on this classification, we recommend that greater emphasis be placed on adequate project assessment to quantify effectiveness in changing ecosystem function and to provide for application of successful methods in other parts of the Great Lakes basin and elsewhere. Selection of effective methods is particularly important in light of the number, cost and diversity of habitat projects underway in the Great Lake basin (Tables 3, 4, and 5) and the planning processes underway (RAPs, LAMPs, fisheries restoration and remediation objectives, fish community goals).

Conceptual Framework

Undertaking remedial action is an admission that environmental quality has deteriorated. When damage to ecosystems occurs, it is reassuring to have a method for repair, but avoiding damage in the first place would have been better. Selection of habitat modification and conservation methods consequently will not be a simple task. Careless application of habitat modification can add to ecosystem damage by enhancing erosion, changing nutrient and energy delivery, favouring undesirable or exotic species and the like. Some of the major factors which must be appreciated in a process leading to selection of a method or methods to modify habitat include:

- consensus about ecosystem objectives, endpoints or targets;
- understanding how physical and chemical habitat features might affect ecosystem structure and function;
- whether habitat was lost or affected and is implicated as a cause of ecosystem change;

Table 3. Organization of the 47 methods of modifying habitat by type or class of management action.

Management Class	Design Goal	Ref. #
Modification to flow or water quantity	reduce local flow in a channelized floodway	2
	reduce fine sediment deposition	4
	create spawning habitat	11
	provide access to river for better water quality	31
	erosion control	22
	allow water to enter wetland which was drying up due to purple loosestrife invasion	12
Water Quality Management	ameliorate acidity	1
	water temperature management	30
	decrease phosphorus input	16
	develop biological criteria to help review dredge and fill permits	32
	increase stream and interstitial pH	9
Physical Habitat Management	create refugia	2, 7, 13, 17, 31, 37
	shade aquatic habitat	2
	create, augment spawning habitat	3, 18, 20, 24, 25, 27, 31, 33, 35, 37, 40, 43, 46
	protect shoreline	5, 6, 13, 16, 22, 23, 34, 40, 41, 46, 47
	create nursery habitat	5
	foster development of wetland	5, 10, 19, 21, 23, 24, 25, 26, 27, 28, 29, 31, 36, 37, 45, 47
	assessment of breakwater effects	42
	repair damage due to storms, etc	34, 35
	improve substrate quality	6, 40, 44
	increase structural complexity	8,12
	re-establish aquatic vegetation in areas degraded by poor water quality and carp activities	12, 31
	restore and enhance estuarine habitat diversity	15
Management of Aquatic and Terrestrial biota	provide nesting habitat for common tern	7
	create lake trout spawning habitat	39
	create pike spawning habitat	12, 20, 33, 36
	create walleye spawning habitat	3, 44
	provide suitable nest structures for Ospreys	14
	establish structural fish habitat (reefs) – improve quality	17, 38, 43, 39
	creation of smallmouth bass spawning habitat	18
	provide critical habitat for resident and migratory fish species, herptiles and birds	15, 33, 34, 29
Controls on Human Activity	control on farming activities	16

Table 4. The status and effectiveness assumed by the project proponent of 47 habitat modification initiatives in the Great Lakes basin.

No.	Title	Status[a]	Known Effectiveness
1	Rehabilitation of the Native Aurora Trout Lakes	1	high; now a reproducing population; continuing monitoring
2	Neebing-McIntyre Floodway Habitat Restoration	2	
3	Current River Estuary Walleye Spawning Habitat	2	unknown if adults will return to spawn
4	Construction of Self-Cleaning Spawning Substrate	N/A	
5	McVicar Creek Mouth Island Creation	2	
6	McVicar Creek Rehabilitation	2	
7	Use of Reefrafts to Create Habitat for Birds and Fish	1	high; terns are successfully using the nesting site -'high' fish use; needs longer evaluation
8	Metro Toronto Waterfront - Restoration of Natural Habitat Structure	3	
9	Mitigation of Low pH in Salmonid Streams	1	'high' initial success; may need future re-application - 8 years of minitoring and will continue
10	Lower Don River Demonstration Wetland Habitat	4	
11	Creating Upwellings as Habitat for Incubation of Eyed Stage Brook Trout (*Salvelinus fontinalis*) Eggs	2	unknown if adults will return to spawn
12	Transplanting Aquatic Vegetation in Collingwood Harbour	2	
13	Soil Bioengineering for Streambank Protection and Fish Habitat Enhancement	1	site #1:'high'; no pre/post biol. study; has exceeded goals site #2: high success rate; pre & post assessment good
14	Restoring Breeding Ospreys in the Upper St. Lawrence River - A Case Study	1	high success; osprey are exceeding expected reproduction values
15	McKellar River Habitat Creation Project	2	
16	Severn Sound Tributary Rehabilitation and Erosion Control Program	2	
17	Underwater Fish Reef Creation Project Within Ashbridge's Bay Park, City of Toronto	2	
18	Col. Samuel Smith Waterfront Park Bass Spawning Area	2	
19	Wetland Plantings Within the Mimico Creek Estuary, Humber Bay Park, City of Etobicoke	1	high; wetland is self propagating; long-term monitoring has been initiated as well as studies in hydrology & sedimentation
20	Toronto Islands Northern Pike Spawning Habitat	2	
21	Metzger Marsh Coastal Wetland Restoration Project	3	

Table 4. (*continued.*)

No.	Title	Status^a	Known Effectiveness
22	Urban Stream Stabilization Efforts Which Increase Instream Habitat While Controlling Bank Erosion	1	high; bank stabilization as reduced erosion and increased river habitat ; under going long-term monitoring
23	Ruwe Marsh Protection Project - Phase 1	4	
24	Windsor Salt Riverfront Rehabilitation Project	4	
25	MacDonald Park Habitat Enhancement Demonstration Project	4	
26	Bear Creek Wetland Creation Project	4	
27	Stag Island Habitat Rehabilitation Project	4	
28	D'Arcy McKeough Floodway Habitat Enhancement Project	4	
29	Aquatic Macrophyte Establishment in McKellar River Embayments at Thunder Bay, Ontario	2	
30	Lake Orion Water Quality - Habitat Improvement Project	1	high; stable water temperature providing more habitat for brown trout ; completed in 1991; long-term monitoring continuing
31	Belle Isle Canal Rehabilitation	3	
32	Lake Erie Biological Criteria and Habitat Evaluation Project	3	
33	Sawquin Creek Marsh Channel Creation Project	1	'high'; possibly temporary without maintenance; completed in 1992 ; needs long-term monitoring
34	Strawberry Island (Niagara River) Shoreline Habitat Restoration and Protection Project	1	high ; repaired damage to shoreline; encouraging future projects to other parts of the island; some pre/post assessment
35	Sand Creek Bank and Channel Restoration	1	high; repaired damage to bank and provided additional habitat project completed in 1986; monitoring continuing
36	Early Life History of Northern Pike In Artificial Wetlands of Conesus Lake, New York	1	'high'; biological assessment of 4 created wetlands; successful creation of pike spawning habitat ; needs long-term monitoring
37	Wayne County Detroit Metropolitan Airport Crosswinds Marsh Wetland Mitigation Project	2	
38	Artificial Reefs in Lake Erie: A Habitat Enhancement Tool	1	high; concentrated fish habitat produced; began in 1984; good pre and post monitoring ; assessment ongoing
39	Burns Harbor Major Rehabilitation - Submerged Breakwater Reefs	3	
40	Pere Marquette River Rehabilitation Project * (project ongoing 1987-1994)	1	high; using pre and post treatment areas for assessment; monitoring will continue

Table 4. *(continued.)*

No.	Title	Status[a]	Known Effectiveness
41	Effects of Beach Nourishment on the Nearshore Environment, Lexington Harbor, Lake Huron	1	'high' ; met goals to repair beach ; 3 years post assessment data would have bennefited from longer assessment ; not done
42	Ecological Effects of Rubble-Mound Breakwater Construction and Channel Dredging at West Harbor, Ohio (Western Lake Erie)	1	'high'; needed longer term monitoring; not done
43	Evaluation of Tawas Artificial Reef as Fish Spawning Habitat	1	high ; hatchery trout have used the subsrtrate for spawning; monitoring to see if adults will return
44	Fox River Walleye Habitat Improvement	1	site #1: low; no change in spawning activity site #2: high; spawning success has exceeded goals site #3: 'moderate'; results slowly showing improvement ; monitoring is continuing at all sites
45	Peterson Wetland Restoration Project	1	'high'; wetland re-watered and habitat improved ; requires long-term monitoring
46	Paint Creek Habitat Improvement (Southeast Michigan) * project ongoing (~1982 - onward)	1	'high'; successfully installed lunker structures have stabilized creek banks; no formal assessment carried out
47	Big Island Wetland, Sandusky Bay , Ohio	1	high; project completed in 1984 ; highly successful wetland; long-term data and monitoring continues

[a] Status Values: 1 = Complete; 2 = Finished - No long-term assessment; 3 = Project started; 4 = Not yet implemented.

Table 5. Organization of 47 methods to modify habitat by technique of intervention.

Technique	Ref. #
embayments	2, 15, 29, 24
creation of upwellings	4, 11, 18, 44
pike channels	12, 20, 33, 36
treatment with powdered limestone	1

submerged or floating structures	2, 7, 13 8,12,17,19, 22,38,39, 40,43,46
bank stabilizers	6,16,22,24,27,31,34,35,40,44,46
islands	5 24,27 5
planting of vegetation	2,10,12,13,16,19,20,21,22,25, 27,28,29,31,34,35, 37,40
substrate modification	3,6,9,18,31,35,40,4245,47
landform modification	10,12,15,20,21,23, 34, 25,27,28,31,34,35, 37,41,42,44,45,47
nesting platforms, bird boxes	14,16,27
water temperature modification	30
develpoment of biological standards (criteria)	32
dyke building	23,25,26,21,42

- the role of habitat modification in relation to other actions, e.g., controls on exploitation, biological intervention which also might affect ecosystem structure and function;
- the effectiveness of altering habitat properties on ecosystem attributes (predictions of the outcome of remedial actions likely will be uncertain for some time; Table 4 and Cairns [1988]);
- sustainability of the ecosystem;
- effects of scale, i.e., local, watershed, basin-wide action;
- "durability" of the modification;
- change in time scale of natural events by the intervention; and
- socio-economics.

If habitat modification is an action option for:

- achieving fish community or ecosystem objectives established within the Great Lakes institutional framework, i.e., habitat modification will lead to progress toward specified, ecosystem-based end points;
- restoring lost or damaged habitat as called for in Annex 2 of the 1987 Protocol to the Great Lakes Water Quality Agreement and in the Strategic Vision of the Great Lakes Fishery

Commission for the decade of the 1990's; or
- rehabilitating habitat or mitigating the effects of habitat degradation in order to improve or enhance ecosystem structure and function;

then the process framework presented in Figure 2 can be used to help select methods to modify habitat. If habitat modification is not required, then the process can be curtailed and efforts for preservation and conservation continue. If habitat modification is required, it is important to identify stakeholders and secure partnerships early in the process. Experience has shown that if agreement on a clear, measureable problem definition is not achieved, the problem usually remains unresolved.

Having agreement on quantitative targets or end points, identifying appropriate methods for modifying habitat requires:
- identifying changes to habitat that have caused biological impacts,
- evaluating supply of the habitat features that have been affected,
- identifying that aspect of habitat which is limiting,
- evaluating habitat modification options,
- assessing potential, unintended negative impacts,
- merging scientific, engineering and economic concerns, and
- priorizing habitat modification options, e.g., wetlands, spawning areas on the basis of their contribution to achieving the problem resolution, and
- selecting actions or methods of modifying habitat.

If objectives, targets or endpoints are not met, the causes of failure and other options need to be analyzed, and the evaluation of management options re-examined (Figure 2). If unintended negative effects arise, the evaluation of management options will require re-examination. If the limiting factor(s) is unknown and the need for habitat modification is not urgent, protection is appropriate, and evaluation of perturbations affecting ecosystem function is required. Each of these situations appears as a loop in the decision making process and any framework for remediation or management must allow for mid-course correction.

Adequate assessment is critical if effectiveness in achieving objectives is to be determined. More importantly, predictive capabilities in ecology are often constrained so habitat modification, when conducted with good scientific method, can strengthen theoretical and applied ecology. Therefore, despite the benefit of making advances in ecology, adequate assessment will indicate when the next priority in habitat modification should be implemented. Testing hypotheses in ecology and evaluating progress toward ecosystem objectives are complementary and reinforcing activities.

Outlook and Challenges

This manual of methods for modifying habitat makes available techniques used or planned for use in the Great Lakes watershed. The methods are less important than the communication that we hope will occur in efforts to select approaches for achieving remediation objectives and goals for ecosystem components. In our view, restoration and remediation initiatives must include determining the objectives and endpoints that guide management, establishing the framework within which

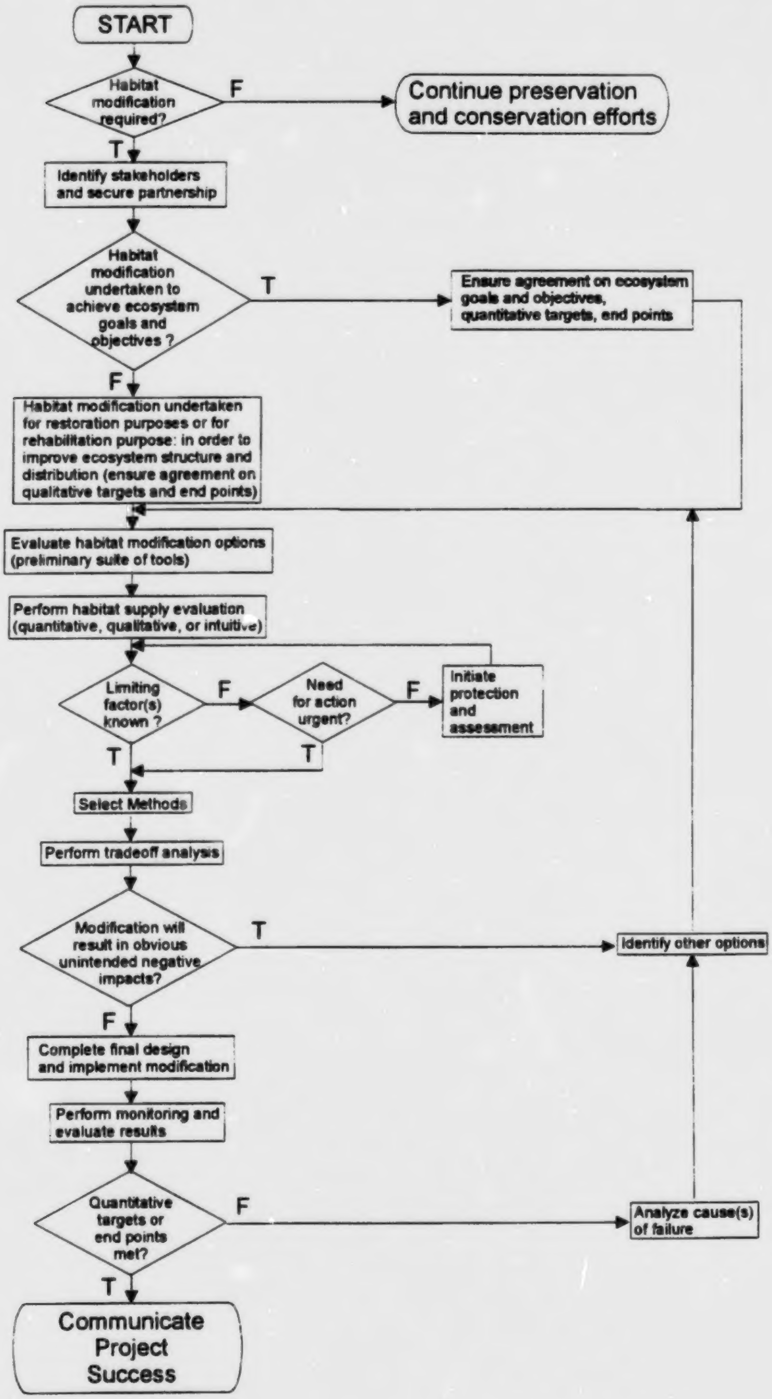
START
Habitat modification required?
F
Continue preservation and conservation efforts
T
Identify stakeholders and secure partnership
Habitat modification undertaken to achieve ecosystem goals and objectives ?
T
Ensure agreement on ecosystem goals and objectives, quantitative targets, end points
F
Habitat modification undertaken for restoration purposes or for rehabilitation purpose: in order to improve ecosystem structure and distribution (ensure agreement on qualitative targets and end points)
Evaluate habitat modification options (preliminary suite of tools)
Perform habitat supply evaluation (quantitative, qualitative, or intuitive)
Limiting factor(s) known ?
F
Need for action urgent?
F
Initiate protection and assesament
T
T
Select Methods
Perform tradeoff analysis
Modification will result in obvious unintended negative impacts?
T
Identify other options
F
Complete final design and implement modification
Perform monitoring and evaluate results
Quantitative targets or end points met?
F
Analyze cause(s) of failure
T
Communicate Project Success

Figure 2.

management actions are addressed, and recognize that restoration ecology, an emerging scientific discipline (Jordan 1988), requires an assessment of effectiveness of the initiatives. Bradshaw (in press) suggests that restoration is a serious test of our ecological understanding. Restoration is likely not only a test for ecology, restoration is an acid test for the strength of partnerships which propose to achieve ecosystem objectives and the logic of frameworks which select management options, as well as the science of ecology.

Continued emphasis must be placed upon merging the scientific, engineering, and socio-economic knowledge needed to advance rehabilitation and sustainability of the Great Lakes ecosystem. Sound assessment programs which value effectiveness of habitat modification therefore must incorporate contributions to ecology (e.g., hypothesis testing, predictive capability), engineering (e.g., tests of design, performance), and socio-economics (e.g., cost-effectiveness, sustainable development). This merger of knowledge and approaches is broadly manifested in the ecosystem approach (Great Lakes Research Advisory Board 1978) and at least the Great Lakes Water Quality Agreement and the Strategic Vision of the Great Lakes Fishery Commission for the decade of the 1990's. Broad, multi-stakeholder partnerships benefit from strong commitments, but benefits to partners also must be present.

Because 55% of the projects to modify habitat available in this manual are incomplete in implementation or assessment, we suggest that re-assessment every 2 years is appropriate. *The Canadian Journal of Fisheries and Aquatic Sciences (Supplement 1)* 1996 will contain an array of papers which review the science and management for habitat conservation and restoration strategies (proceedings of the HabCARES, Nov. 1994, workshop). The methods outlined in this manual and the workshop proceedings reflect our current status and knowledge related to conservation and restoration in the Great Lakes basin. Like the framework proposed for selecting appropriate methods of modifying habitat (Figure 2), continued assessment of the process, progress and problems ensures achieving the most effective program for maintaining ecosystem form and function.

Acknowledgements

The agencies and individuals reflected in the 47 projects of this manual deserve recognition for their insight in designing the projects and their industry in implementing the ideas. C. Wooley, A. Behm, K. Fuller, H. Shear, D. Dodge (members of the Habitat Advisory Board), and J. Shaw (Canada's Great Lakes 2000 Cleanup Fund) have been particularly helpful in identifying contributors for this manual. Susan Stoddart and Lisa O'Connor helped us contact contributors and electronically organize submissions.

The "Conceptual Framework" and Figure 2 were adapted from the efforts of a working group at the HabCARES workshop and will be published as a perspectives paper in the *Can. J. Fish. Aquat. Sci. (Suppl.1) 1996*.

L. Newman, S. Metikosh, D. Dodge, R. Steedman, K. Minns, C. Wooley, and H. Shear provided helpful reviews and advice during important stages of compiling this manual.

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Location of initiatives describing methods of modifying habitat to benefit the Great Lakes ecosystems and designation as Area of Concern.

No.	Title	Location	AOC/Non-AOC
1	Rehabilitation of the Native Aurora Trout Lakes	Whirligig and White Pine Lakes -Temagami	Non-AOC
2	Neebing-McIntyre Floodway Habitat Restoration	Neebing-McIntyre Rivers -Thunder Bay	AOC
3	Current River Estuary Walleye Spawning Habitat	Current River	AOC
4	Construction of Self-Cleaning Spawning Substrate	theoretical	N/A
5	McVicar Creek Mouth Island Creation	McVicar Creek	AOC
6	McVicar Creek Rehabilitation	McVicar Creek	AOC
7	Use of Reefrafts to Create Habitat for Birds and Fish	Metro Toronto Waterfront	AOC
8	Metro Toronto Waterfront - Restoration of Natural Habitat Structure	Metro Toronto Waterfront	AOC
9	Mitigation of Low pH in Salmonid Streams	Fifteen Mile Brook - Nova Scotia	Non-AOC
10	Lower Don River Demonstration Wetland Habitat	Lower Don River	AOC
11	Creating Upwellings as Habitat for Incubation of Eyed Stage Brook Trout (*Salvelinus fontinalis*) Eggs	Grand Portage Streams, Lake Superior	Non-AOC
12	Transplanting Aquatic Vegetation in Collingwood Harbour	Collingwood Harbour	AOC
13	Soil Bioengineering for Streambank Protection and Fish Habitat Enhancement	Collingwood Harbour	AOC
14	Restoring Breeding Ospreys in the Upper St. Lawrence River - A Case Study	Upper St. Lawrence River	AOC
15	McKellar River Habitat Creation Project	McKeller River	AOC
16	Severn Sound Tributary Rehabilitation and Erosion Control Program	Severn Sound Tributaries	AOC
17	Underwater Fish Reef Creation Project Within Ashbridge's Bay Park, City of Toronto	Metro Toronto Waterfront	AOC
18	Col. Samuel Smith Waterfront Park Bass Spawning Area	Metro Toronto Waterfront	AOC
19	Wetland Plantings Within the Mimico Creek Estuary, Humber Bay Park, City of Etobicoke	Metro Toronto Waterfront	AOC
20	Toronto Islands Northern Pike Spawning Habitat	Metro Toronto Waterfront	AOC
21	Metzger Marsh Coastal Wetland Restoration Project	Metzeger Marsh - SW basin of Lake Erie	AOC
22	Urban Stream Stabilization Efforts Which Increase Instream Habitat While Controlling Bank Erosion	Waukegan River	AOC
23	Ruwe Marsh Protection Project - Phase 1	Ruwe Marsh, Detriot River	AOC
24	Windsor Salt Riverfront Rehabilitation Project	Detroit River	AOC
25	MacDonald Park Habitat Enhancement Demonstration Project	St. Clair River	AOC
26	Bear Creek Wetland Creation Project	St. Clair River	AOC
27	Stag Island Habitat Rehabilitation Project	St. Clair River	AOC
28	D'Arcy McKeough Floodway Habitat Enhancement Project	Sydenham, St. Clair Rivers	AOC
29	Aquatic Macrophyte Establishment in McKellar	McKellar River - Thunder Bay	AOC

	River Embayments at Thunder Bay, Ontario		
30	Lake Orion Water Quality - Habitat Improvement Project	Lake Orion - Paint Creek, MI	AOC
31	Belle Isle Canal Rehabilitation	Belle Isle Detriot R.	AOC
32	Lake Erie Biological Criteria and Habitat Evaluation Project	L. Erie Biological Criteria Survey	Non-AOC
33	Sawquin Creek Marsh Channel Creation Project	Sawquin Creek Marsh-Bay of Quinte	AOC
34	Strawberry Island (Niagara River) Shoreline Habitat Restoration and Protection Project	Strawberry Isl.- Niagara River	AOC
35	Sand Creek Bank and Channel Restoration	Sand Creek- Kalamazoo River	AOC
36	Early Life History of Northern Pike In Artificial Wetlands of Conesus Lake, New York	Lake Conesus, NY	AOC
37	Wayne County Detroit Metropolitan Airport Crosswinds Marsh Wetland Mitigation Project	Wayne County Detroit Marsh Wetland	AOC
38	Artificial Reefs in Lake Erie: A Habitat Enhancement Tool	Lorain Harbour, Cleveland Harbour	AOC
39	Burns Harbor Major Rehabilitation - submerged breakwater reefs	Burns Harbour	Non-AOC
40	Pere Marquette River Rehabilitation Project	Pere Marquette River	Non-AOC
41	Effects of Beach Nourishment on the Nearshore Environment, Lexington Harbor, Lake Huron	Lexington Harbor, L. Huron, MI	Non-AOC
42	Ecological Effects of Rubble-Mound Breakwater Construction and Channel Dredging at West Harbor, Ohio (Western Lake Erie)	West Harbor, Western L. Erie	Non-AOC
43	Evaluation of Tawas Artificial Reef as Fish Spawning Habitat	Tawas Bay, MI	Non-AOC
44	Fox River Walleye Habitat Improvement	Fox River	AOC
45	Peterson Wetland Restoration Project	Peterson Wetland, Clinton County, MI	Non-AOC
46	Paint Creek Habitat Improvement (Southeast Michigan)	Paint Creek, MI	AOC
47	Big Island Wetland, Sandusky Bay , Ohio	Big Island Wetland, Sandusky Bay, Ohio	Non-AOC

Project 1

1. **Project Title: Rehabilitation of the Native Aurora Trout Lakes**

2. **Contact**

Ed Snucins or John Gunn
Co-operative Freshwater Ecology Unit, Ontario Ministry of Natural Resources, Dept. of Biology,
Laurentian University, Sudbury, Ontario P3E 2C6
Tel.: (705) 675-1151; FAX (705) 675-4859; E-mail: JGUNN@Nicel.Laurentian.Ca

3. **Agencies Involved**

Ontario Ministry of Natural Resources
Ontario Ministry of the Environment and Energy
Laurentian University
and support through the World Wildlife Fund

4. **Restoration Goal**

To improve the water quality in one of the native aurora trout (*Salvelinus timagamiensis*) lakes and reestablish a reproducing population of aurora trout.

5. **Project Type**

Amelioration of lake acidity by treatment with powdered limestone.

6. **Background and Rationale**

The aurora trout is a unique genetic stock of the brook trout that is distinguished by its colouration. Its entire range consists of only two small lakes (Whirligig and Whitepine) located about 100 km north of Sudbury, Ontario. Acidification of the lakes by atmospheric deposition of pollutants resulted in the extirpation of the aurora trout from its range during the 1960's. The aurora trout was saved from extinction by a captive breeding program that began in 1958 and in 1987 it was placed on the Canadian endangered species list.

During the 1980's, natural water quality recovery was occurring in many lakes in the Sudbury area following reductions in local metal smelter emission levels, but the aurora trout lakes were slow to respond and their acidic water quality continued to be limiting for aurora trout survival. By the late 1980's, numerous attempts to establish reproducing populations of aurora trout in other lakes where the population was not indigenous had failed and there was growing concern about the adverse effects of prolonged domestication on the fitness of the stock. Therefore, if the acidification problem could be eliminated, the best chance of quickly reestablishing a self-sustaining wild population would be in Whirligig and Whitepine lakes. Whole-lake liming, a proven technique for temporarily ameliorating lake acidity and increasing brook trout survival (Gloss et al. 1989), was done in Whirligig Lake and aurora trout were re-introduced following the treatment.

7. Regulatory Considerations

a) Generally, an Environmental Assessment permit from the Ministry of Natural Resources (MNR) District office would be required; however, this was waived because the project involved reintroduction of a native fish stock.
b) Permission from the MNR Temagami District was required for the use of aircraft and boats/motors on Whirligig and Whitepine lakes because they are located in a Provincial Preserve.

8. Criteria

A minimum pH of 5.0 is required for aurora trout reproduction. However, increasing lake pH to 6.5 would provide suitable water quality ($pH > 5.0$) for a number of years even if gradual reacidification occurred.

9. Project Design

Whirligig Lake and its headwater, Little Whitepine Lake, were both treated in 1989 with powdered calcite to achieve a post-liming pH of 6.5 and an alkalinity of 2.0-3.5 mg/L in each lake. Whirligig Lake became reacidified and was treated again in 1993.

10. Implementation

The neutralizing material was powdered calcite (mean diameter 5 µm, 96% $CaCO^3$). The application rate was calculated using a PC-compatible version of the "Deacid" model developed by Harold Sverdrup in Sweden for the U.S. Acid Precipitation Mitigation Program (Sverdrup and Warfvinge 1985). The model calculates the calcite dose needed to achieve user-defined end points from starting chemical conditions. Model input variables include the following: lake surface area, volume, water residence time, pH, Ca, DOC, and alkalinity.

The material was transported to the lakes by helicopter from the nearest road, a distance of about 10 km. In 1989, 21 tonnes of calcite were spread manually by emptying bags of the material into the propeller wash of a boat. This treatment succeeded in raising the pH of both lakes to 6.5. Adult and juvenile aurora trout were released into Whirligig Lake in 1990.

Whirligig Lake gradually reacidified and in 1993 it was treated with 6 tonnes of calcite. This time the material was applied by releasing it from a bag suspended below a helicopter. An additional 3 tonnes of calcite were stored on shore for future use, if necessary.

11. Degree of Environmental Intervention

There were no negative effects.

12. Cost

	1989	1993
Labour and materials	$7 200	$4 100
Aircraft	$9 000	$2 200
Total	**$16 200**	**$6 300**
	($771/tonne)	($700/tonne)

Biological Assessment ~ $2 500/yr
Monitoring will be continued for one more year (1995) and then possibly be cut back to every 5 years.

13. Biological Assessment

The water quality (pH, alkalinity, conductivity, metals, nutrients, ions, Al speciation) of the treated lakes is monitored each year at monthly intervals throughout the ice-free period. Biotic community (macrobenthos, phytoplankton, zooplankton) species composition and abundance are also determined annually.

Schnabel mark-recapture estimates of aurora trout population abundance are obtained each year during the fall spawning season. Fish growth, diet, spawning site characteristics and reproductive success are also monitored.

14. Measures of Success

Successful reproduction by the introduced aurora trout has occurred every year. Individual fish growth is comparable to historical values in the native lakes and by 1991 the biomass of aurora trout had increased to levels typical of healthy brook trout populations in unacidified lakes.

Success Rating: 4

Continued survival of the aurora trout in Whirligig Lake depends on maintaining water quality. It is hoped that the legislated 1994 Sudbury metal smelter emission reductions will be sufficient to delay or possibly even prevent reacidification. Water quality monitoring will continue and the lake will be treated again if necessary.

Whitepine Lake, the other lake where aurora trout were native, is located downstream from Whirligig Lake and its water quality has also improved (pH 5.2 in 1994). Aurora trout were reintroduced to Whitepine Lake in 1994.

15. Key References

Gloss, S.P., Schofield, C.L., Spateholts, R.L., and Plonski, B.A. 1989. Survival, growth, reproduction, and diet of brook trout (*Salvelinus fontinalis*) stocked into lakes after liming to mitigate acidity. Can. J. Fish. Aquat. Sci. 46: 277-286.

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Correct citation for this contribution:

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Project 2

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1. Project Title: Neebing-McIntyre Floodway Habitat Restoration

2. Contact

Ken Cullis
North Shore of Lake Superior Remedial Action Plans, 1194 Dawson Road, R.R. #12, Site 8-16,
Thunder Bay, Ontario P7B 5E3
Tel.: (807) 768-2106; FAX (807) 768-1889; E-mail: CULLIS.KEN@A1@NRNWOA

3. Agencies Involved

North Shore of Lake Superior Remedial Action Plans*, 1194 Dawson Road, R.R. #12, Site 8-16, Thunder Bay, Ontario P7B 5E3
(* Includes Environment Canada, Great Lakes Cleanup Fund, Ontario Ministries of Natural Resources and Environment and Energy.)

Great Lakes Laboratory for Fisheries and Aquatic Sciences, Department of Fisheries and Oceans, 1 Canal Drive, Sault Ste. Marie, Ontario P6A 6W4

4. Restoration Goal

Diversify fish habitat in a homogenous floodway.

5. Project Type

Construction of underwater log pile, log mat, and boulder pile structures. Construction of protected, shaded embayments.

6. Background and Rationale

Until 1983, the Neebing and McIntyre rivers entered Lake Superior within 1 km of each other. Because occasional flooding damaged adjacent residential areas, the narrow, meandering lower portions of the two rivers were filled and replaced with a single straight, wide (≈35 m) channel devoid of instream structure. The littoral zone was restricted to a very narrow (<1.5 m) strip along either bank and shoreline and aquatic vegetation was sparse. However, upstream portions of both rivers were known for spring and fall rainbow trout spawning runs and resident brook trout populations. Walleye and yellow perch were also present in both river systems. We attempted to create refugia and restore a portion of the original instream habitat diversity to benefit immigrating spawning fish and emigrating juveniles.

7. Regulatory Considerations

a) Completion of an Ontario Ministry of Natural Resources Class Environmental Assessment for Water Related Excavation, Dredging, and Fill Activities.
b) File a Government of Canada Environmental Assessment Review Process Screening Decision Document.
c) Obtain an Ontario Ministry of Natural Resources Work Permit.
d) Ensure rock fill added to the floodway conforms with the Ontario Ministry of Environment and Energy Lake Filling Guidelines.

8. Criteria

The embankment modification and structures could not interfere with flood control properties of the floodway, nor could they cause reduced bank stability. Traffic corridors for small boats were to be maintained.

9. Project Design

In a 1.25 km section of the floodway four embayment structures and eight groupings of log mats, log pilings, and boulder piles were created (Figure 1).

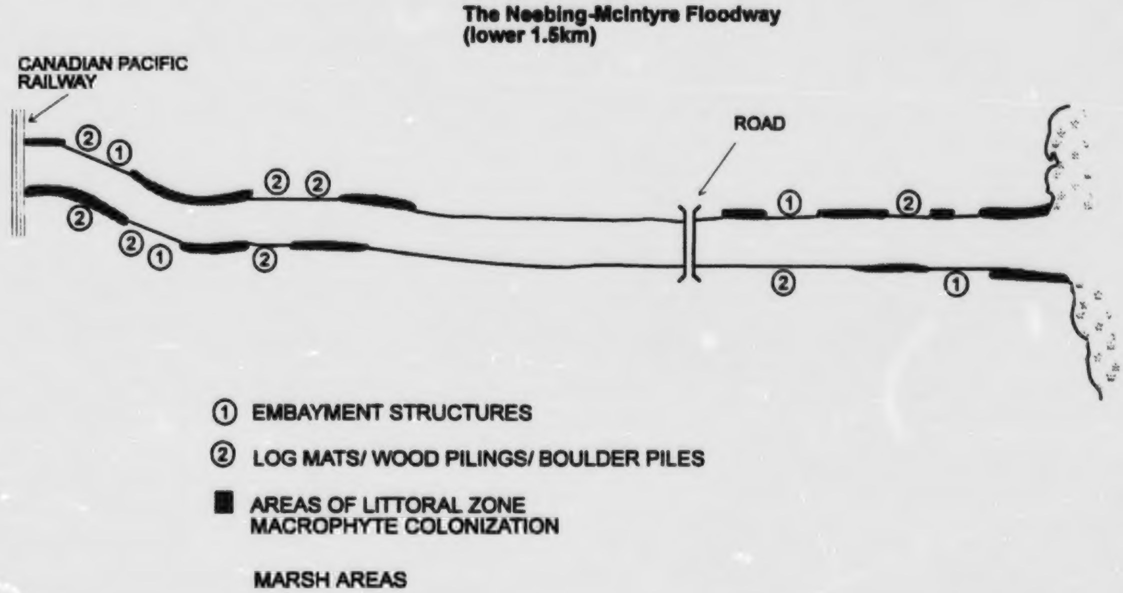
The Neebing-McIntyre Floodway
(lower 1.5km)
CANADIAN PACIFIC RAILWAY
ROAD
① EMBAYMENT STRUCTURES
② LOG MATS/ WOOD PILINGS/ BOULDER PILES
■ AREAS OF LITTORAL ZONE MACROPHYTE COLONIZATION
MARSH AREAS

Figure 1

The embayment structures were designed to reduce flow rates locally, and to diversify littoral habitat in the floodway. Overhead vegetative cover provided shaded resting areas for fish and some degree of protection from predation by birds and mammals.

The log mat/wood pilings/boulder pilings structures were designed to provide refugia and overhead cover.

10. Implementation

This project was implemented in 1991. The embayment structures (Figure 2) were constructed in three stages. First, earth was excavated and stockpiled. Rock fill (average diameter 300 mm,

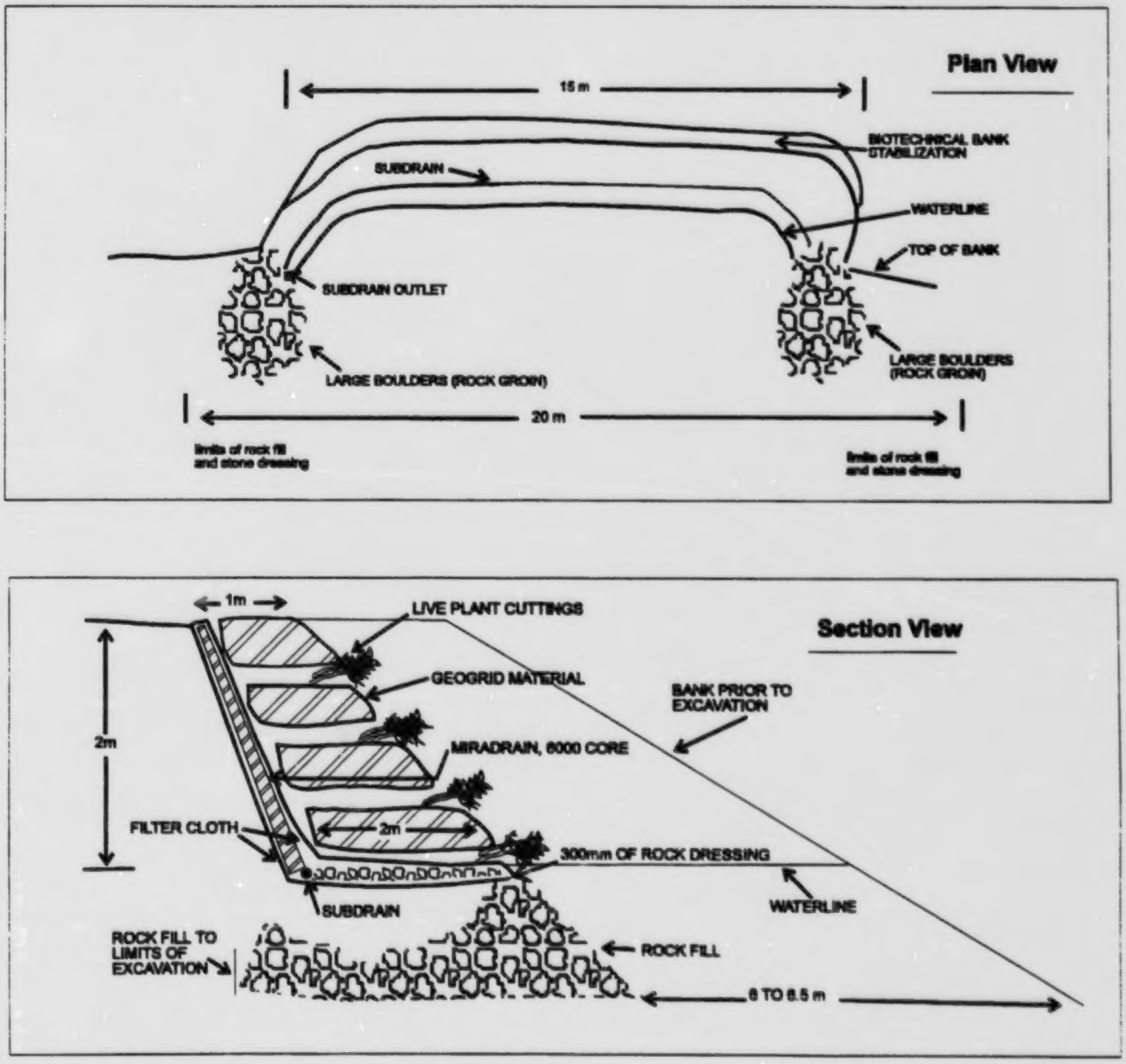
Plan View
15 m
BIOTECHNICAL BANK STABILIZATION
SUBDRAIN
WATERLINE
TOP OF BANK
SUBDRAIN OUTLET
LARGE BOULDERS (ROCK GROIN)
LARGE BOULDERS (ROCK GROIN)
20 m
limits of rock fill and stone dressing
limits of rock fill and stone dressing
Section View
1m
LIVE PLANT CUTTINGS
GEOGRID MATERIAL
BANK PRIOR TO EXCAVATION
MIRADRAIN, 6000 CORE
2m
2m
FILTER CLOTH
300mm OF ROCK DRESSING
WATERLINE
SUBDRAIN
ROCK FILL TO LIMITS OF EXCAVATION
ROCK FILL
6 TO 6.5 m

Figure 2

granite) was placed above and below the water line to provide both bank stabilization and refugia in the interstices. Finally, earth fill, geogrid (Tensar BX1200 (SS2)) and live plant cuttings (local plants, e.g., willow, dogwood, and alder, 15-25 mm as well as 60 mm in diameter) were placed above the water line. Geotextile fabric (Terrafix 400 NR), Miradrain (6000 core by Mirafix), subdrain (corrugated plastic drainage tubing) and rock dressing (average diameter 100 mm, granite) were placed as shown in Figure 2. At the terminals of each area of bank stabilization, Armour stone (large boulders, 300-1000 kg, granite) were placed perpendicular to the stream flow.

The log mat/wood pilings/boulder pile structures were placed as shown in Figure 3. The wood piles (rough poplar, 4-5 m in length, minimum diameter of 300 mm) were driven into the substrate, large end first, so that the tops of the piles were a minimum of 1 m below the surface of the water. Boulder pilings were constructed by excavating areas to be filled to a minimum depth of 1 m. Geotextile (as above) and rock fill (as above) were placed in the excavated areas. Log mats were constructed by driving wood pilings (rough poplar, minimum length of 6 m) into the substrate in clusters. Wood logs were placed among the clusters with one end into the bank and one end against the pile cluster in a fashion which prevented the log mats from floating downstream. Plant cuttings were planted on the top of the bank.

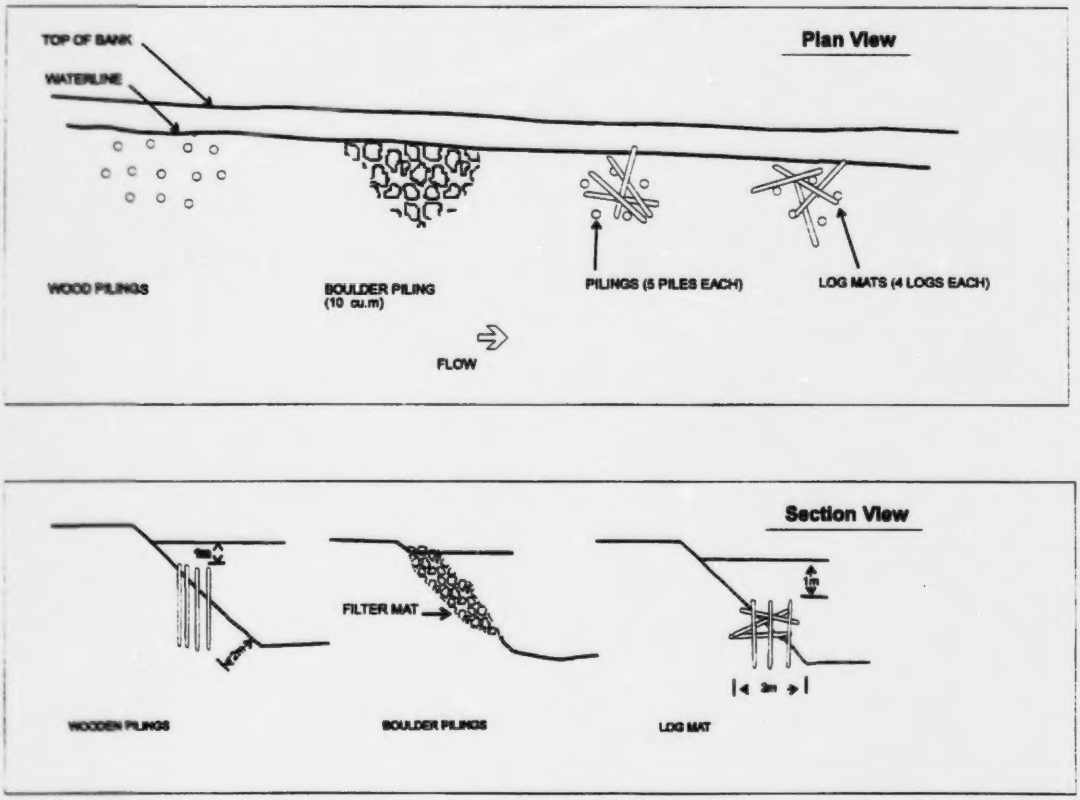
TOP OF BANK
Plan View
WATERLINE
WOOD PILINGS
BOULDER PILING (10 cu.m)
PILINGS (5 PILES EACH)
LOG MATS (4 LOGS EACH)
FLOW
Section View
1m
2m
FILTER MAT
1m
2m
WOODEN PILINGS
BOULDER PILINGS
LOG MAT

Figure 3

11. Degree of Environmental Intervention

Four embayment structures affected a total of approximately 60-80 m of shoreline and required at least 96 m^3 of armour stone. At each site the bottom of the bank was excavated 6.0-6.5 m back from the original.

In total, the eight groups of log mat/log piling/boulder piles required approximately 80 m^3 of rock fill and 480-560 m of rough poplar. These structures affected approximately 150 m of shoreline.

12. Cost

Construction:	
Materials and Construction	$96 514
Engineering Support	$13 375
Subtotal, Construction	$109 889
Assessment (estimated):	
Field Crew (2 person weeks/year, 5 years)	$7 200
Sr. Scientist/Biologist (2 person weeks)	$2 000
Data Analysis/Reporting ($3,000/year, 5 years)	$15 000
Subtotal, Assessment	$24 200
Total Estimated Project Cost	**$134 089**

13. Biological Assessment

Assessment techniques include electrofishing (done to give $\#/m^3$), quantitative seining and mid-channel trawling as well as benthic sampling.

14. Measures of Success

The structures should act as centres for aggregation of fish, resident and migrating. An increase in diversity or abundance of fish populations, especially an increase in the number of juvenile salmonids and other sport fish, should also occur. Survival of emigrating juvenile fishes should be enhanced.

Success Rating: 1

Fish abundance and diversity are greater in the embayments than along unaltered stretches of shoreline. It is unclear whether the localized increases are indicative of increased overall abundance, diversity, and survival in the floodway.

15. Key References

None.

Correct citation for this contribution:

Cullis, K. 1995. Neebing-McIntyre floodway habitat restoration, p. 21–26. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 3

1. Project Title: Current River Estuary Walleye Spawning Habitat

2. Contact

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3. Agencies Involved

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P7B 5E3
(* Includes Environment Canada, Great Lakes Cleanup Fund, Ontario Ministries of Natural Resources and Environment and Energy)

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4. Restoration Goal

Compensate for walleye (*Stizostedium vitreum*) spawning habitat removed by dredging.

5. Project Type

Augmentation of remnant, and creation of new, walleye spawning habitat.

6. Background and Rationale

The Current River walleye stock is one of the few remaining self-sustaining walleye stocks in Lake Superior (Schram et al. 1991). Over the past 130 years spawning habitat has been lost or modified in the Current River by the effects of a silver stamp mill (1870's), saw mill (late 19th century), road and railway construction (late 19th to early 20th century), river impoundment for water management (≈1905), and construction of a boat launching and docking facility (1984).

We selected three sites of similar size for augmentation in the Current River estuary (Figure 1). The total surface area of the three sites approximated one half the area of habitat suitable for walleye spawning removed by dredging for dock construction. Two sites were downstream extensions of known remnant spawning areas in lotic sections of the estuary. The third site was influenced more by Lake Superior than the river but was also suspected to have been used historically for spawning.

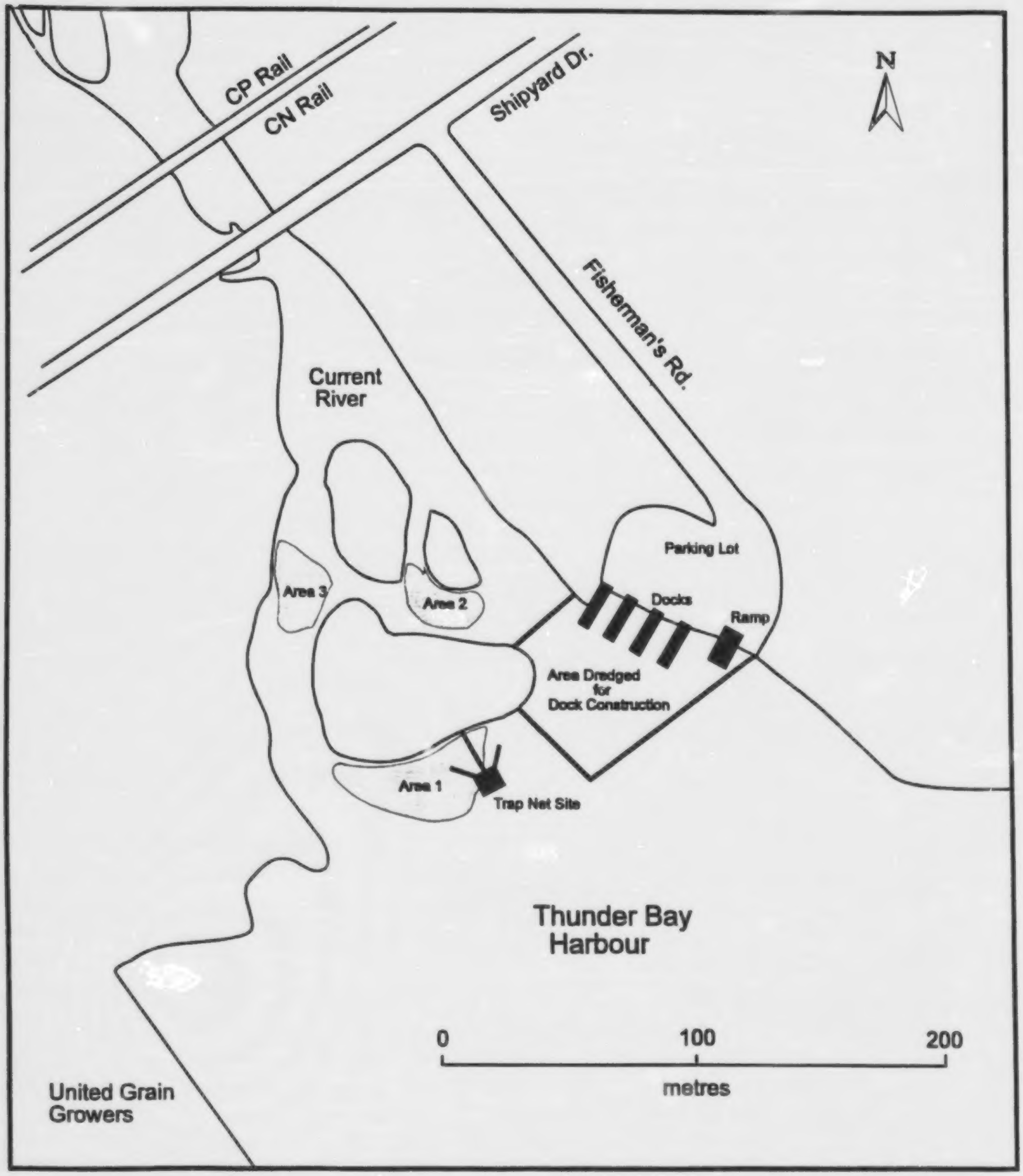
N
CP Rail
CN Rail
Shipyard Dr.
Fisherman's Rd.
Current River
Parking Lot
Area 3
Area 2
Docks
Ramp
Area Dredged for Dock Construction
Area 1
Trap Net Site
Thunder Bay Harbour
0
100
200
metres
United Grain Growers

Figure 1. Current river estuary showing trap net, dock dredging, and spawning substrate addition sites.

7. Regulatory Considerations

a) Completion of an Ontario Ministry of Natural Resources Class Environmental Assessment for Water Related Excavation, Dredging, and Fill Activities.
b) Completion of an Application for Approval for Work under the Fill, Construction, and Alteration to Waterways Regulations administered by the Lakehead Region Conservation Authority.
c) File a Government of Canada Environmental Assessment Review Process Screening Decision Document.
d) Obtain an Ontario Ministry of Natural Resources Work Permit.
e) Ensure rock fill added to the estuary conforms with the Ontario Ministry of Environment and Energy Lake Filling Guidelines.

8. Criteria

Walleye are known to exhibit preference (Hartley and Kelso 1991) for spawning in:

- Predominately gravel/cobble substrate;
- Water depth < 2.5 m with preference for depths < 1.2 m;
- Current velocities in streams ranging from 14 to 150 cm/s in the bottom one third of the water column

In lakes, spawning areas must be subject to wave-induced or wind-induced currents strong enough to prevent siltation.

9. Project Design

We attempted to duplicate the channel width, depth, flow diversity, and substrate characteristics of the two remnant spawning areas in constructing the two downstream lotic sites. No attempt was made to modify the existing flow pattern of the river as it separated into three channels at the mouth, and we did not affect the remnant successful spawning areas. The project was also designed to test benefits from spawning habitat augmentation in lotic and lacustrine sites in the same estuary.

10. Implementation

The project was completed in one week of December 1991, except for some minor site clean up which took less than one day in the summer of 1992. The substrate added was clean, silt free, igneous stone from a local quarry which was crushed and sized to our specifications. We used three diameters of stone: gravel (5-20 mm diam.), cobble (100-250 mm diam.), and boulders (500-750 mm diam.). All substrate used was free from contaminants and debris.

The total surface area of the three sites was approximately 1 700 m^2. To this area we added 225 tonnes each of gravel and boulders and 125 tonnes of cobble. Placement of materials was by tracked backhoe, with care taken to not disturb the areas around the augmentation sites.

In the lotic sites cobble was spread as evenly as possible followed by an evenly spread gravel layer. This substrate assemblage was tapped down with the backhoe shovel to shake the gravel down and to set the cobble into the channel bed. Randomly placed individual boulders were then added to disrupt flow patterns and to act as instream cover.

In the lacustrine site, cobble was spread as evenly as possible followed by a random distribution of boulders. This assemblage was tapped down into the substrate with the backhoe shovel. A layer of gravel was added on top of the cobble/boulder assemblage. It was assumed that wave action would imbed the gravel among the coarser substrate.

11. Degree of Environmental Intervention

Morphometry, microhabitat water velocities, and substrate characteristics were primarily affected. Original materials of the stream bed or estuary were not removed. Rather, the new material was superimposed. No mortality to fish or macroinvertebrates and no evidence of increased downstream sedimentation were observed. Placement of material was in December when flow was low and spawning by species whose reproductive habits are known was non-existent. Winter (Jan. to mid Mar.) and late summer (mid July to end Aug.) construction of spawning habitat would be acceptable alternatives.

12. Cost

Labour and Materials	$30 000	
Engineering Support	$5 000	
On-Site Supervision	$2 500	
Subtotal, Construction	$37 500	($22.06/m²)
Assessment costs (estimated):		
Field crew (10 person weeks/year, 5 years)	$36 000	
Biologist (1 week/year, 5 years)	$5 000	
Gas, Oil, Net Repair, Supplies	$1 000	
Subtotal, Assessment	$42 000	
Total Estimated Project Cost:	**$79 500**	

NOTE: To achieve efficiencies of scale, construction of this project was tendered in conjunction with another local project. Therefore the construction cost quoted is a best estimate.

13. Biological Assessment

Mark and recapture population estimates of walleye vulnerable to a 1.8 m trap net (50 mm stretched mesh) were derived during the spawning runs in 1991, 1992, and 1993. The methodology will be replicated at least twice in the years 1996 to 1999 to evaluate any change in recruitment to the population. Qualitative diving surveys of egg deposition in the estuary were conducted in 1991 and 1993. Seining surveys for young-of-the-year walleye were conducted in 1991-1993 and may be continued in conjunction with future population estimations. The estuary was also visually surveyed with powerful spotlights at night to detect the presence of spawning adults during the 1993 spawning run.

14. Measures of Success

If the enhancement or increase in spawning area for walleye is successful, increases of either or both total egg deposition and fry production in the estuary would be expected. Ultimately, these increases will lead to increased abundance and/or harvest of adult walleye using the estuary for spawning.

The 1993 diving survey found viable walleye eggs in the historic and newly created lotic spawning habitat. Eggs were not found in the lacustrine site. Complete assessment is not possible until the 1992 and subsequent year-classes become recruited to the spawning population.

Success Rating: 4

but it is unknown whether abundance of spawning walleye will increase.

15. Key References

Hartley, K.A., and Kelso, J.R.M. 1991. Habitat information and rehabilitation alternatives for restoring spawning habitat of walleye and salmonids in streams. Can. Tech. Rep. Fish. Aquat. Sci. 1813: iv + 60 p.

Schram, S.T., Atkinson, J.R., and Pereira, D.L. 1991. Lake Superior walleye stocks: status and management, p. 1-22. *In* P.J. Colby, C.A. Lewis, and R.L. Eshenroder [*editors*]. Status of walleye in the Great Lakes: case studies prepared for the 1989 workshop. Great Lakes Fish. Comm. Spec. Publ. 91-1.

Correct citation for this contribution:

Geiling, D. 1995. Current River estuary walleye spawning habitat, p. 27–31. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 4

1. **Project Title: Construction of Self-Cleaning Spawning Substrate**

2. **Contact**

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3. **Agencies Involved**

North Shore of Lake Superior Remedial Action Plans*, 1194 Dawson Road, Thunder Bay, Ontario P7B 5E3
(* Includes Environment Canada, Great Lakes Cleanup Fund, Ontario Ministries of Natural Resources and Environment and Energy)

Department of Fisheries and Oceans, Great Lakes Laboratory for Fisheries and Aquatic Sciences, 1 Canal Drive, Sault Ste. Marie, Ontario P6A 6W4

4. **Restoration Goal**

Provision of spawning substrate which will remain free of fine sediment deposition.

5. **Project Type**

Construction of an upwelling through a man-made spawning bed.

6. **Background and Rationale**

Fish spawning habitat has been rendered inaccessible or degraded in quality by anthropogenic influences including deposition of fine sediments. Barrier construction, urban and agricultural development may cause increased erosion and sedimentation of spawning habitat. In many cases, correction of sedimentation problems in spawning habitat may require extensive and costly rehabilitation of not only spawning habitat, but also the upstream sources of increased sedimentation.

Construction of self-cleaning spawning habitat may be a localized alternative to extensive riverine rehabilitation. By creating an upwelling through man-made spawning habitat it is possible to locate spawning habitat in zones of fine sediment deposition. The force of upwelling water will prevent sedimentation of the spawning habitat itself, without altering significantly the hydrologic characteristics of the reach in which the habitat is constructed.

7. Regulatory Considerations

Compliance with Provincial, State, Federal, Municipal, or other environmental assessment regulations as they apply to instream works (intake site and distribution system) and terrestrial works (pipeline). In Ontario this will include compliance with the Navigable Waters Protection Act, the Fisheries Act, and the Ontario Ministry of Environment and Energy's Lake Filling Guidelines.

8. Criteria

The force of upwelling must repel fine sediment deposition while not dislodging deposited eggs. The system should be as close to maintenance-free as possible. Thus, available hydraulic head must be utilized to drive the system rather than pumps or other mechanical means. The area of spawning habitat will vary according to head available. Spawning habitat design should allow for placement in a range of depths (usually < 3.0 m) with substrate particle size tailored to the species targeted.

9. Project Design

The self-cleaning substrate system consists of a water intake connected by piping to a distribution manifold. The distribution manifold, or network of piping which contains small diameter orifices, underlies a man-made spawning bed with particle sizes tailored to the requirements of the targeted species. High density polyethylene pipe (HDPE) is recommended while polyvinylchloride pipe (PVC) is an acceptable alternative.

Flow through the system is continuous but will vary according to available hydraulic head and base flow at the intake. As the spawning substrate will be free from sediment initially, the up-flow needs only to maintain suspended particles in the water column. The up-flow velocity to accomplish this is significantly less than that required to flush substrate laden with fine sediment, thus reducing the size (and expense) of the piping and trenches required.

An up-flow velocity of 0.07 m/s has been assumed in design calculations. This velocity is sufficient to maintain in suspension particles approximately 0.6 mm in diameter and smaller. Also assumed is a porosity value of 15% on a horizontal plane for the spawning substrate. Using these assumptions, a minimum 0.6 m hydraulic head is required to provide sufficient flow volume from the distribution network to the spawning substrate. The hydraulic head is defined as the difference in elevation between the surface of the water at the intake site and the spawning habitat.

The maximum area of the spawning bed can be estimated from the availability of flow at the intake location. Select two locations on the stream, one above and one below the candidate intake site. The locations should be at least 50 m apart unless the stream is very steep. Measurements for base flow calculations should be taken during a period of low flows to ensure that adequate water is available to the intake year round.

To calculate base flow, measure the cross sectional area of the stream and wetted perimeter at both locations. Also required is the difference in elevation of the surface of the water and the distance between the locations to calculate the slope of the water surface. Base flow is then calculated as follows:

$$\text{Base Flow } (m^3/s) = 28.6 \quad \frac{(A)^{1.67}\ (S)^{0.5}}{(P)^{0.67}}$$

where: A = Average Cross Sectional Area (m^2)
P = Average Wetted Perimeter (m)
S = Slope of Water Surface (m/m)

Maximum spawning area size (m^2) can be estimated by multiplying the base flow value by 22.5.

Table 1. Ranges of man made spawning bed sizes (m^2) possible depending upon the available hydraulic head and pipeline diameter used. This table can be used for pipe lengths up to 200 m.

Head Height	Pipe Diameter (mm)		
(m)	150	315	630
0.6	0.0 – 2.7	7.7 – 11.0	33.8 – 44.1
0.7	0.0 – 3.5	9.9 – 14.2	43.6 – 56.9
0.8	0.0 – 4.2	11.7 – 16.8	51.6 – 67.3
0.9	0.0 – 4.7	13.3 – 19.0	58.5 – 76.3
1.0	0.0 – 5.2	14.7 – 21.0	74.7 – 84.4
1.1	0.0 – 5.7	16.0 – 22.9	70.3 – 91.7
1.2	0.0 – 6.1	17.2 – 24.6	75.5 – 98.5
1.3	0.0 – 6.5	18.3 – 26.2	80.4 – 104.9
1.4	0.0 – 6.9	19.3 – 27.7	85.0 – 110.9
1.5	0.0 – 7.2	20.3 – 29.1	89.3 – 116.6
1.6	0.0 – 7.6	21.1 – 30.4	93.5 – 122.0
1.7	0.0 – 7.9	22.1 – 31.7	97.5 – 127.2
1.8	0.0 – 8.2	23.0 – 33.0	101.3 – 132.2
1.9	0.0 – 8.5	23.8 – 34.2	105.0 – 137.0
2.0	0.0 – 8.8	24.6 – 35.4	108.5 – 141.6
2.1	0.0 – 9.1	25.4 – 36.5	112.0 – 146.1
2.2	0.0 – 9.3	26.2 – 37.6	115.3 – 150.2
2.3	0.0 – 9.6	26.9 – 38.6	118.6 – 154.7
2.4	0.0 – 9.9	27.6 – 39.7	121.7 – 158.9
2.5	0.0 – 10.1	28.3 – 40.7	124.8 – 162.9
2.6	0.0 – 10.4	29.0 – 41.6	127.8 – 166.8
2.7	0.0 – 10.6	29.7 – 42.6	130.7 – 170.7
2.8	0.0 – 10.8	30.3 – 43.5	133.6 – 174.4
2.9	0.0 – 11.1	31.0 – 44.5	136.4 – 178.1
3.0	0.0 – 11.3	31.6 – 45.4	139.2 – 181.7

Having measured the available hydraulic head, final size and location of the spawning area can be determined using cost/benefit analysis. Costs will increase with distance between the intake and spawning area as well as with pipeline diameter required. Benefits may increase with increasing spawning area size.

Table 1 provides a condensed version of the range of man-made spawning bed sizes which are possible given various hydraulic head and pipeline diameter values. An expanded version of this information can be found in Wm. R. Walker Engineering Inc. (1994).

10. Implementation

The intake consists of two concentric sections of corrugated steel culvert pipe (1.2 and 1.8 m diam.) which are welded to a 6 mm plate steel base. A length of steel bell-mouth pipe, equal in diameter to the pipeline leading to the manifold, penetrates through both culvert walls. The culvert sections should be 0.9 m long if the pipeline diameter is 300 mm or less, otherwise they should be 1.2 m. The space between the culvert pipes should be filled with rock to sink and anchor the intake. The opening above the inner culvert should be covered with 25 mm mesh fibreglass screen.

The pipeline connecting the intake with the distribution manifold should be buried in a trench. Width of the trench should be at least 0.8 m plus pipe diameter, while the depth should be at least 1.35 m plus pipe diameter. The pipe should be laid in a compacted sand bedding which is at least 150 mm thick below the pipe and 300 mm above the pipe. The balance of the trench may be backfilled with compacted native material. The pipeline should have a downward gradient along its entire length, although the slope need not be constant.

Geotextile filter fabric should be laid on the stream bed prior to substrate placement. The filter fabric should be overlain with a 150 mm layer of granular material (max. particle diam. 25 mm) to provide a bed for the distribution piping. The distribution manifold can consist of a single pipe supplying a 1.0 m wide rectangular spawning bed, or it may consist of a series of paralell pipes spaced at 1.0 m intervals. In the case of a single distribution pipe, the pipe diameter will be the same as the pipeline from the intake. In multiple pipe systems, the product of the length of the spawning bed and the 1.0 m width of substrate the pipe is to supply is termed the contingent area. Using the contingent area as the equivalent of bed size and the known hydraulic head, Table 1 can be used to determine the diameter required for the distribution pipes.

Two lines of orifices (25 mm diam.) should be drilled into each distribution pipe. One line of orifices should be drilled on each side of the pipe half way between the top and the maximum horizontal width of the pipe. The orifices in each line should be spaced 150 mm apart, and the two lines should be offset such that one orifice is present for every 75 mm of pipe. Granular material

(37-75 mm diam.) should be placed around each pipe to prevent clogging. A layer of spawning substrate extending to 0.5 m beyond the edge of the outermost distribution pipes can then be added. The spawning substrate layer should be 200 mm thick above the tops of the pipes, and can be comprised of stone ranging in sizes from 10 to 125 mm.

The outer slopes of the spawning area should be armoured with 100 to 250 mm rock. The armouring should extend from the top of the spawning area to the stream bed at a slope of 3:1 or greater (horizontal:vertical).

11. Degree of Environmental Intervention

The degree of intervention will vary between application sites. Some trees may have to be removed to facilitate trench digging but the effects of these losses on the stream can be minimized by locating the trench away from the stream bank. Construction of the in-stream components will likely displace a small amount of sediment, but this too can be minimized by construction during a period of low flows. Significant direct negative impacts on biota are not expected.

12. Cost

The following unit costs have been provided by Wm. R. Walker Engineering Inc. (1994). All costs quoted are estimates in 1994 Canadian dollars. Actual costs may vary significantly depending on the characteristics of the site selected.

Piping: HDPE pipe, includes installation and all fittings.

Pipe Diam. (mm)	Cost per metre
150	$ 74
315	$ 86
630	$132

Intake:

- Inlet pipe diameter 315 mm or less: Allow $1 500
- Inlet pipe diameter greater than 315 mm: Allow $2 500

Substrate Bed:

- Material sourced on site: $ 12 per m^3
- Material trucked to site: $ 18 per m^3

Thus, the approximate cost of a 25 m^2 (5 m × by 5 m) spawning bed constructed with trucked-in materials and located 100 m from the intake (315 mm pipe) would be:

Intake:		$1 500
Piping:	Pipeline 100 m @ $ 86 /m	$8 600
	Distribution 6 * 5 m @ $ 86 /m	$2 580
Substrate Bed:	$25\ \mathrm{m}^2 * 0.7\ \mathrm{m}\ @\ \$\ 18\ /\mathrm{m}^3$	$300
	Armouring allowance (est.)	$300
		$13 280

13. Biological Assessment

Measurement of egg deposition and hatching success prior to and following construction are suggested.

14. Measures of Success

The project can be considered a success if the following conditions are met:

1. Egg deposition and survivorship are increased on the man-made spawning area as compared to the same area of substrate before construction,
2. Sedimentation of the man-made spawning area does not occur, or occurs so slowly that the area remains viable for many years without requiring maintenance, or
3. If periodic, but infrequent, flow dependent flushing is sufficient to provide sediment free substrate during critical spawning periods.

An alternative method of measuring success would be to monitor fish production on the spawning area over time. Economic value of the fish produced over time could then be compared to the cost of construction and subsequent maintenance.

Success Rating: 1

The system described herein has yet to be tested in the field. However, similar but less rigorously designed systems have been constructed in the Nipigon River (Savioja and Kushnier 1991, Ont. Min. Nat. Res. unpubl. report). Results from these trials have been mixed, but evidence of brook trout (*Salvelinus fontinalis*) spawning on portions of one of the two project sites has been reported. Lack of success at one site was attributed to overly strong flows through the substrate while sedimentation occurred on portions of the other project site. It is possible that the Nipigon River results could have been improved had flow rates through the spawning substrate been more tightly controlled.

15. Key References

Wm. R. Walker Engineering Inc. 1994. Report on Self-Cleaning Stream Substrate System. Job # 93/74. Sault Ste. Marie, Ont.

Correct citation for this contribution:

Geiling, D. 1995 Construction of self-cleaning spawning substrate, p. 32–38. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 5

1. Project Title: McVicar Creek Mouth Island Creation

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4. Restoration Goal

Protect the mouth and shoreline to the immediate south of McVicar Creek from wave action and foster the growth and redevelopment of an historic wetland.

5. Project Type

Construction of a semicircular island with diversity in terrestrial and aquatic habitat.

6. Background and Rationale

Since 1982, the waterfront to the south of the McVicar Creek mouth has been developed into a park and marina complex. A road overpass was constructed in 1985 as part of this complex. The lakeward embankment of the overpass infilled a small wetland area adjacent to the creek mouth and hardened the shoreline.

McVicar Creek has supported spring spawning runs of at least rainbow trout (*Oncorhynchus mykiss)* and smelt (*Osmerus mordax*). More recently, low survival of young rainbow trout spawned in the creek has been attributed at least partially, to the loss of nursery habitat at the mouth.

The island was constructed in 1993 to protect the shoreline to the south of the creek mouth, and to a lesser extent the mouth itself, from wave action. The sheltered area will recreate nearshore nursery habitat and foster redevelopment of the historic wetland.

7. Regulatory Considerations

a) Completion of an Ontario Ministry of Natural Resources Class Environmental Assessment for Water Related Excavation, Dredging, and Fill Activities.
b) File a Government of Canada Environmental Assessment Review Process Screening Decision Document.
c) Obtain an Ontario Ministry of Natural Resources Work Permit.
d) Ensure rock fill added to the estuary conforms with the Ontario Ministry of Environment and Energy Lake Filling Guidelines.

8. Criteria

The basic structure should be constructed of locally available rock and be able to withstand the erosional forces of ice and waves. The crest elevation and width should prevent overtopping by

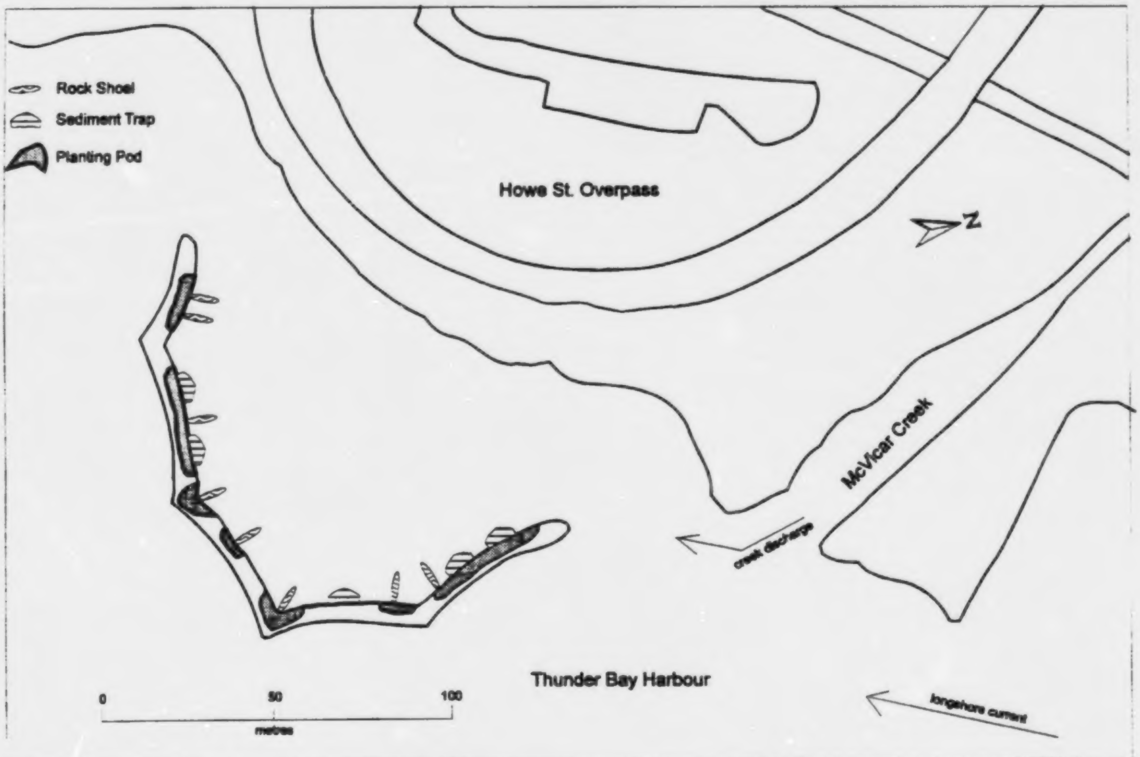

Rock Shoal
Sediment Trap
Planting Pod
Howe St. Overpass
N
McVicar Creek
creek discharge
Thunder Bay Harbour
longshore current
0
50
100
metres

Figure 1. Plan view of Sanctuary Island.

waves. The structure should be shaped, sized, and positioned to protect the shoreline to the south of and including the creek mouth, and to trap sediments transported by the creek and longshore currents. Sufficient space between the island and mainland will be left to maintain water circulation and prevent the formation of a solid peninsula.

9. Project Design

Discharge from the creek is deflected to the south by a sandbar at the mouth. Longshore currents also follow a roughly north to south pattern. Thus, the island was positioned just to the south of the creek mouth.

A semicircular rock berm formed the basic structure of the island (Figure 1). This shape was chosen to enhance the likelihood of sediment deposition on the lee side of the island. To accelerate this process, semicircular and straight rock shoals were constructed on the lee side of the island. These elements also served to diversify underwater habitat which had been limited to a gradually sloping sandy silt substrate largely lacking in macrophyte growth since the construction of the road overpass.

Pockets of protected soil were built into the lee slope of the island. These pockets were placed above the waterline, and are large enough to support clusters of native shrubs and small trees. As the plantings grow, the shaded area and allochthonous inputs to the lee of the island will increase.

10. Implementation

A temporary causeway was built from just south of the creek mouth to the northernmost point of the island site. All materials were trucked to the island and shaped by backhoe. When completed, the island was 205 m long, with the northern end of the island 40 m offshore and the southern end 30 m offshore. At the centrepoint, the island is 85 m offshore. Water depth off the lee shore ranged from 1.5 to 2.8 m, not including underwater structures. The causeway was removed after completion of all structural elements of the island.

The core of the island was composed of 1-450 mm quarry run stone (approx. 11 000 tonnes), and was sloped at a 1.5:1 (horizontal:vertical) ratio from the substrate to the long-term mean Lake Superior water level. The core was overlain with 100-450 mm quarry stone (approx. 14 000 tonnes) at the same slope such that a crest 5 m wide and roughly 2 m above water level was formed. This layer was 3 m thick on the lakeward slope of the island, and 1 m on the lee slope. All quarry stone was clean, local igneous rock, which was free from silt, shale, and organic matter.

Five semicircular subsurface structures acted as sediment traps. Each was 10 m long and extended 4 m out from the island. The sediment trapping structures were constructed on top of a bed of clean quarry screenings placed at a slope of 1.5:1 such that the top of the trap was a half metre below the water surface (Figure 2a). The trapping structures were lined with filter cloth and filled to a depth of 30 cm with fine gravel (1-25 mm).

Eight rock shoals, each 5 m wide, were constructed off the lee of the island at a slope of 3:1. Each shoal contains a core of quarry screenings covered with a 1 m thick layer of 100-450 mm stone (Figure 2b).

Seven soil pockets of varying length were excavated into the lee of the island to a depth of approx-

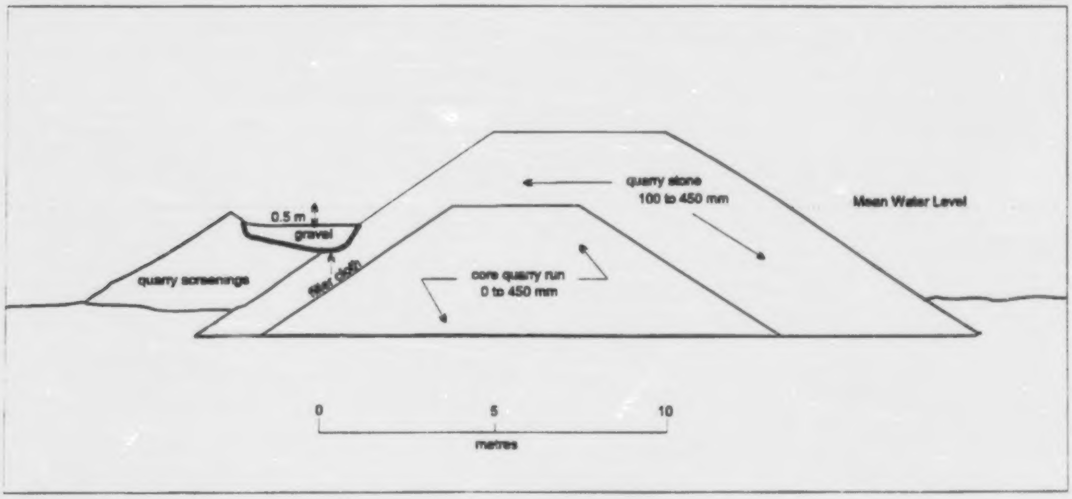
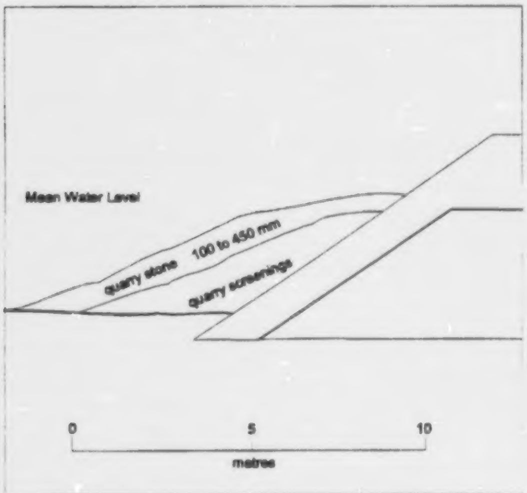

quarry stone
100 to 450 mm
Mean Water Level
0.5 m
gravel
filter cloth
quarry screenings
core quarry run
0 to 450 mm
0
5
10
metres

Figure 2a. Cross section of the island, with a typical cross section of a sediment trap.


Mean Water Level
100 to 450 mm
quarry stone
quarry screenings
0
5
10
metres

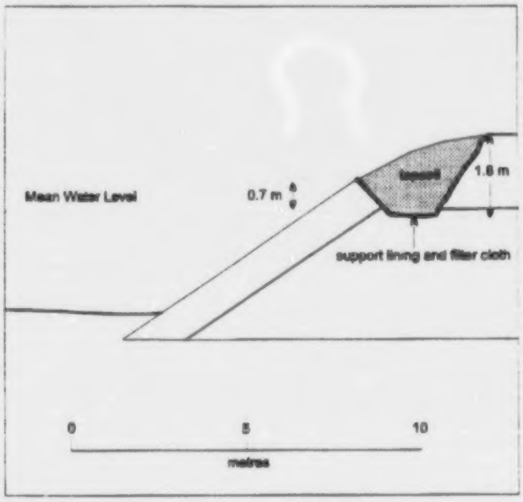

Mean Water Level
0.7 m
topsoil
1.8 m
support lining and filter cloth
0
5
10
metres

Figure 2b. Cross section of a typical rock shoal.

Figure 2c. Cross section of a typical soil pocket.

imately 1.8 m, partially below the mean water level to ensure moisture availability to the soil. The excavated basin was lined with fine gravel and filter cloth prior to topsoil addition (Figure 2c). Each pocket was fertilized, seeded with a mixture of grasses, and covered with an organic, biodegradable erosion control mat to stabilize the soil. Planting of indigenous shrubs and small trees will follow. The lower lip of the pockets are 0.7 m above mean lake level to help prevent soil erosion.

11. Degree of Environmental Intervention

Culverts were installed in the temporary causeway to avoid deflection of longshore currents during construction. Mortality, while unseen, would probably be limited to the macroinvertebrate community. Given the barren homogeneity of the substrate upon which the island was constructed, this mortality was probably limited. The dumping of tonnes of rock caused a temporary, localized suspension of native sediments which was mitigated by performing all construction during winter. Ice cover prevented wave action from transporting the disturbed sediments away from the construction site.

12. Cost

Construction:	
Labour and Materials	$280 000
Engineering Design/Support	$50 000
Contract Administration	$25 000
On-Site Supervision	$25 000
Subtotal, Construction	$380 000
Assessment (estimated):	
Field Crew (2 person weeks/year, 5 years)	$7 200
Benthos Sample Sorting and Taxonomy (*n*=100)	$5 000
Data Analysis & Reporting ($1,000/year)	$5 000
Subtotal, Assessment	$17 200
Total Estimated Project Cost	**$397 200**

13. Biological Assessment

Fish using the area to the lee of the island will be monitored where possible by beach seining in spring, summer, and fall. This seining effort will be supplemented with a late summer electrofishing effort using boat mounted gear.

Benthic macroinvertebrates will be sampled using a petite Ponar dredge in each of June and October. Each effort will consist of three samples off the lakeward shore of the island and seven samples to the lee of the island. Locations will not be fixed, but will include samples from across the range of depth present.

The macrophyte community will be qualitatively sampled in the summer to monitor colonization of the lee of the island. Annual counts and identification of bird nests on the island will also be included.

All monitoring effort will be geared toward tracking changes in vegetation and fauna on and to the lee of the island over time. Assessment will be qualitative, at least over the first few years following construction.

14. Measures of Success

Maturation of the island and the area to the lee of the island is recognized as being a slow process. Thus we have not set quantitative short-term goals for this project. In the longer term, success will be estimated for a number of criteria including:

1. an increase through time in the use of the lee area by juvenile salmonids,
2. use of the area for spawning by resident fish populations (e.g., centrarchids, yellow perch),
3. reestablishment of a wetland area,
4. increased abundance and diversity of macrophyte and macroinvertebrate communities, and
5. establishment of nesting sites by birds.

Success Rating: 1

Assessment of this project has only just begun. Encouraging signs to date include the sighting of a smallmouth bass on a nest and an increase in macrophyte abundance to the lee of the island.

15. Key References

None.

Correct citation for this contribution:

Geiling, D. 1995. McVicar Creek Mouth Island Creation, p. 39–44. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 6

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1. **Project Title: McVicar Creek Rehabilitation**

2. **Contact**

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3. **Agencies Involved**

North Shore of Lake Superior Remedial Action Plans*, 1194 Dawson Road, Thunder Bay, Ontario P7B 5E3
(* Includes Environment Canada, Great Lakes Cleanup Fund, Ontario Ministries of Natural Resources and Environment and Energy)

Department of Fisheries and Oceans, Great Lakes Laboratory for Fisheries and Aquatic Sciences, 1 Canal Drive, Sault Ste. Marie, Ontario P6A 6W4

4. **Restoration Goal**

Prevent erosion of the modified creek banks and improve creek bed substrate quality.

5. **Project Type**

Creek bank stabilization and replacement of a fine sediment laden rocky creek bed.

6. **Background and Rationale**

In 1985, a road overpass was constructed beside the lower 120 m of McVicar Creek. Sand and debris eroded from embankments, slumped into the creek, settled on the creek bottom, and accreted in the estuary. As a result, interstices in the creek bed were filled and passage of anadromous fish to the upper reaches of the creek was impeded.

McVicar Creek has supported spring spawning runs of at least rainbow trout and smelt. Walleye have also been reported in the lower creek in May, but whether they have used the creek for spawning is uncertain.

Bank stabilization works and replacement of the creek bed were initiated in December 1991. The portion of work not completed by the end of March 1992 was resumed in October 1992. Bank stabilization, replacement of the creek bed, and terracing of the lower portion of the road embankment were completed by December 1992. The road embankment was seeded with grasses, and 600 mixed conifers indigenous to the area were planted in the summer of 1993. To ensure the stability of soils on the embankment, further plantings of up to 1700 mixed shrubs, deciduous and coniferous trees (all indigenous to the area) will be completed in 1994.

7. Regulatory Considerations

a) Completion of an Ontario Ministry of Natural Resources Class Environmental Assessment for Water Related Excavation, Dredging, and Fill Activities.
b) File a Government of Canada Environmental Assessment Review Process Screening Decision Document.
c) Obtain an Ontario Ministry of Natural Resources Work Permit.
d) Ensure rock fill added to the estuary conforms with the Ontario Ministry of Environment and Energy Lake Filling Guidelines.

8. Criteria

Stabilization of the road overpass embankment and creek banks are fundamental concerns. Secondary issues include the removal of any impediment to upstream migration by fish and recreating spawning habitat in the lower creek. Vegetation and landscaping works were used to combat erosion on the road overpass embankment rather than inclusion of hard structures. Creek bank stabilization structures should not preclude the redevelopment of riparian vegetation.

9. Project Design

Trees were planted on the upper portion of the road overpass embankment to begin stabilization of the soil. Two terraces were designed for the lower portion of the embankment such that materials which eroded during construction and landscaping were less likely to reach the creek. The upper terrace served initially as road access to the site; ultimately, both terraces can be used as walkways along the lower creek.

Gabion mats were dug into the creek banks to prevent slumping of the banks into the creek. The mats will gradually fill in with organic matter and materials transported by surface runoff, allowing for gradual revegetation of the shoreline. The lakeward end of the terraced area was protected from wave action by the placement of armour stone (Figure 1).

Rocky substrate removed from the creek bed by excavation was replaced with a clean assemblage of rock suitable as spawning habitat for rainbow trout, smelt, and walleye. These new materials were placed to allow for unimpeded passage of fish to the upper reaches of the creek, but were not arranged to not create a channelized ditch of uniform depth. The width of the creek was restored to approximate pre-overpass conditions.

10. Implementation

A strip of land to the south of and parallel to the lower creek was leveled to provide access to the site. This strip would later become the upper terrace (Figure 1). Excavating equipment worked its way from the roadway bridge downstream when shaping the banks for gabion mat placement and creation of the lower terrace.

The southern (embankment) creek bank was shaped at a 2:1 horizontal:vertical slope. The slope extended 5 m up from the creek bed. A strip not less than 2.4 m wide was leveled above this slope to form the lower terrace. The slope of the north shore was not altered, but the ground was smoothed to facilitate the placement of gabion mats. From the roadway bridge to 15 m downstream, the northern shore was smoothed from the creek bed to 7 m up the slope, while the rest of the shore was smoothed 8 m wide.

The excavated slopes were lined with filter cloth prior to placement of the gabion mats. The gabion mesh was laid in place and the mats were filled by hand. Rock sizes used for gabion fill

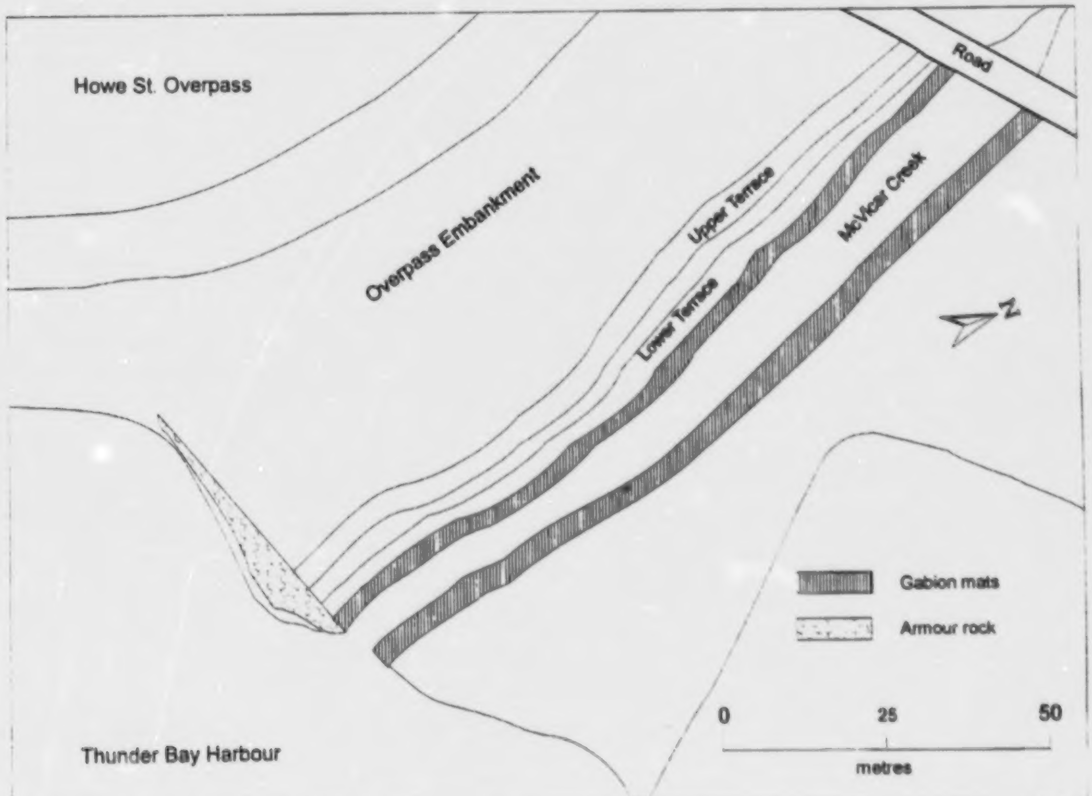
Howe St. Overpass
Road
Overpass Embankment
Upper Terrace
Lower Terrace
McVicar Creek
N
Gabion mats
Armour rock
0
25
50
metres
Thunder Bay Harbour

Figure 1. Plan view of the lower reach of McVicar Creek. Creek, terraces, and gabion mats not to exact scale.

ranged from 80 to 140 mm. Each mat is 230 mm thick, and was divided by additional gabion meshing into cells 1000 mm by 3000 mm.

The creek bed was excavated wherever fine sediment loading was visually apparent. Excavated materials were trucked off site. Clean cobble (100-250 mm, 205 tonnes) and gravel (5-20 mm, 105 tonnes) were evenly spread among the excavated areas. Final shaping of the creek bed distributed the substrate into a mat averaging about 500 mm thick. This mat is 16 m wide at the roadway bridge narrowing to 5 m wide 26 m downstream. From 26 m downstream to 52 m, the creek bed narrows further to 3 m. The 3 m width is maintained to the mouth of the creek.

After the creek bed was complete, boulders (500-750 mm, 100 tonnes) were randomly placed in the creek along the entire length of the project. The boulders serve to both deflect the currents in the lower creek and to provide refugia.

Armour rock (600 mm minimum, 700 tonnes) was placed along the shoreline to the south of the creek mouth to protect the ends of the terraces and exposed embankment shoreline from wave action. The armour rock was placed back from the shoreline to allow for the redevelopment of a wetland area which existed prior to overpass construction.

The overpass embankment is largely composed of an assemblage of sizes of inorganic granular fill. This material was first smoothed and then covered with a 100 mm thick layer of topsoil (3800 m^2). The topsoil was in turn covered with biodegradable straw erosion control mats. Volunteers planted 600 donated mixed conifers through holes cut in the mats to help stabilize the soils. Grasses were not planted as the topsoil was not sterilized and contained the seeds of various plants.

Excavation of the creek and banks, gabion mat and new substrate placement, and terracing works were initiated in the period December 1991 to March 1992. All of these works were completed between October and December 1992. Landscaping of the embankment and tree planting were completed in the spring and fall of 1993. Augmentative plantings will occur in the summer of 1994 to ensure the stability of embankment soils.

11. Degree of Environmental Intervention

At one time or another, the entire project site was directly impacted by heavy construction equipment. The sparse vegetation on the overpass was largely removed during reshaping of the embankment. Remaining vegetation was covered by topsoil. No effort was made to save resident biota during excavation of the creek bed. However, winter excavation of the creek bed mitigated the effect on fish populations as few fish would be present and no species whose eggs incubate in the substrate over winter were known to use the lower reach of the creek for spawning. The benthic macroinvertebrate community would have been primarily affected.

12. Cost

Construction:	
Labour and Materials	$145 000
Engineering Design/Support	$25 000
Contract Administration	$20 000
On-Site Supervision	$10 000
Landscaping	$15 000
Subtotal, Construction	$215 000
Assessment (estimated):	
Field Crew (1 person week/year, 5 years)	$3 600
Data Analysis & Reporting ($500/year)	$2 500
Subtotal, Assessment	$6 100
Total Estimated Project Cost	**$221,100**

NOTES: To achieve efficiencies of scale, construction of this project was tendered in conjunction with another local project. Therefore the cost quoted is a best estimate. Also, all costs quoted above except landscaping were inflated by the necessity of changing construction contractors half way through the project.

13. Biological Assessment

Assessment of the McVicar Creek project will be qualitative. The creek mouth has been sampled with a beach seine in spring, summer, and fall each year since 1990. Seine sampling will continue at least until 1996. The use of the lower creek by spawning fish will be visually monitored in daylight in spring and fall. Night visual surveys using a high-powered hand-held spotlight will be added during May to monitor walleye and smelt use of the lower creek.

14. Measures of Success

Success will be estimated in terms of the fish community and the physical environment. The project will be deemed at least a partial success if:

1. the overpass embankment is stabilized and doesn't contribute erosional materials to the lower creek,
2. the substrate of the lower creek remains largely sediment free and fish migration is not impeded, and
3. the gabion mats become vegetated.

Complete success will be assumed if spawning by species in addition to smelt occurs in the lower creek.

Success Rating: 1

Final plantings to stabilize the overpass embankment have yet to occur, thus assessment of the physical component of this project is not yet possible. However, early results of fish community monitoring are encouraging. Smelt still use the lower creek for spawning in the spring. Also, chinook salmon have been observed to spawn in the lower creek in the fall of 1992 and 1993. Evidence of chinook spawning in the lower creek prior to rehabilitation is lacking.

15. Key References

None.

Correct citation for this contribution:

Geiling, D. 1995. McVicar Creek rehabilitation, p. 45–50. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 7

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1. Project Title: Use of Reefrafts to Create Habitat for Birds and Fish

2. Contacts

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3. Agencies Involved

Metropolitan Toronto Parks and Properties

4. Restoration Goal

To provide nesting habitat for Common Terns and shelter for fish.

5. Project Type

Construction of reefrafts and their installation at suitable locations. Reefrafts are floating wooden platforms with strips of plastic snow fence hanging down from the bottom of the platform.

6. Background and Rationale

Common Terns at the Toronto waterfront have been declining sharply in numbers due to encroachment of their nesting areas at the Eastern Headland by nesting gulls and by vegetation. For terns, the presence of large numbers of gulls constitutes an impairment to the use of their traditional nesting habitat. Traditionally, Common Terns have been a highly visible component of the avifauna of the Toronto Waterfront.

During the 1990 breeding season a project was undertaken to construct and install large wooden rafts for use as nesting habitat by Common Terns. Attracted by wooden painted decoys and suitable substrate, common terns immediately colonized the rafts and fledged chicks. The project continued in 1991 and 1992, again with excellent results. The only drawback of the project was the need to remove the rafts before freeze-up (to prevent damage) and to reinstall them in the spring when the terns first started to return from their wintering grounds in South America. In 1993 tests were carried out with "reefrafts" that differed from the original tern raft in that (1) reefrafts use floatation materials that can withstand ice pressure (thus obviating the need to remove and reinstall the raft), and (2) an artificial reef made out of plastic was suspended below the raft to create habitat for fish. Electrofishing under, near, and away from the reefrafts in the summer/fall of 1993 and 1994 showed that the reefrafts were used by fish. Common Terns used the reefrafts during 1993 and 1994 to the same extent as they used the original nesting rafts during 1990-1992.

7. Regulatory Considerations

a) Environmental assessment: probably not required.
b) Safety aspects: the rafts should be installed in accordance with regulations to prevent boating accidents.

8. Criteria

Common Terns prefer insular sites for nesting (to prevent predation by ground predators) and they prefer open substrate with little and low vegetation (Blokpoel et al. 1978). Common Terns are fairly "manageable" in that they readily colonize new areas and respond to decoys.

Fish of several species readily use the overhead shelter provided by the platforms as well as the additional protection offered by the reefs.

9. Project Design

After installation of the reefrafts, we added earth, sand, pebbles, and driftwood to create a suitable nesting substrate for the Common Tern. Once chicks became mobile we added a ramp to each reefraft that allowed chicks that might fall off the reefraft to get back on to it. Reproductive success of the terns was monitored by regular visits to determine fates of eggs and chicks.

The "reefs" were attached to the bottom of the reefraft when it was being assembled during installation in the water. Fish use of the reefrafts was monitored by electrofishing.

10. Implementation

During 1990-1994, the numbers of original rafts and reefrafts were as follows:

	Eastern Headland	Trout Pond, Toronto Islands
1990	4 Original Rafts	–
1991	4 Original Rafts	–
1992	4 Original Rafts	–
1993	2 Original Rafts & 2 Reefrafts	1 Reefraft
1994	2 Original Rafts & 2 Reefrafts	1 Reefraft

Original rafts and reefrafts were 5 × 5 m. The nesting substrate was spread evenly and had a depth of 2.5-5 cm. Further information on design and effectiveness of the original rafts are given in Dunlop et al. (1991, 1992); further information on the reefrafts is provided by McNicholl et al. (1995) and Jarvie and Blokpoel (1993).

11. Degree of Environmental Intervention

Although no studies were undertaken, we believe that the original rafts and reefrafts did not have any negative effects on the local biotic communities or on the abiotic aquatic environment.

12. Costs

Materials and labour to construct one reefraft:	$3 500
Costs to transport, launch, install and anchor a reefraft:	variable
Costs to monitor effectiveness (= biological assessment):	variable
Costs for annual maintenance:	variable

13. Biological Assessment

Original rafts and reefrafts were routinely visited to monitor nesting chronology and reproductive success of Common Terns (Dunlop et al. 1991; McNicholl et al. 1995).

Electrofishing was carried out under/near the original rafts, under/near the reefrafts, and in open water (control) in 1993 (Jarvie 1993) and 1994 (Jarvie 1994).

14. Measures of Success

The project had excellent results for Common Terns in that during 1991-1994 at least 50 chicks fledged from each raft (or reefraft) in each year.

Success rating for birds: 4

The project appears also successful for fish, but unfortunately electrofishing was carried out on only three occasions so the supporting data are limited. The number of fishes caught on those three occasions was as follows:

	Mean	Range
at/under reefraft	13.3	0-30
at/under original raft	9.5	5-19
control (open water)	5.7	0-13

Success rating for fish: 4

15. Key References

Blokpoel, H., Catling, P.M., and Haymes, G.T. 1978. Relationship between nest sites of Common Terns and vegetation on the Eastern Headland, Toronto outer Harbour. Can. J. Zool. 56: 2957-2061.

Dunlop, C., Blokpoel, H., and Jarvie, S. 1992. Nesting rafts as a management tool for a declining Common Tern (*Sternahirundo*) colony. Colonial Waterbirds 14: 116-120.

Dunlop, C., Blokpoel, H., and Jarvie, S. 1991. Guidelines for the construction and assembly of nesting rafts for Common Terns. 6p. (Unpublished report)

Jarvie, S. 1993. Results of electrofishing during the summer and fall of 1993. (Unpublished report)

Jarvie, S. 1994. Results of electrofishing during the summer and fall of 1994. (Unpublished report)

McNicholl, M.K., Blokpoel, H., and Jarvie, S. 1995. Ecology of Common Tern nesting on rafts along the Toronto Waterfront, 1991-1993. (In preparation)

Correct citation for this contribution:

Blokpoel, H., and Jarvie, S. 1995. Use of reefrafts to create habitat for birds and fish, p.51–54. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech, Inf.) Occas. Pap. No. 1.

Project 8

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1. Project Title: Metro Toronto Waterfront – Restoration of Natural Habitat Structure

At the time of writing, this habitat project is still in the planning phase. Funding is in place from three sources (Ontario Ministries of Natural Resources, and Environment and Energy, as well as Great Lakes Cleanup Fund). Implementation (placement of habitat structure) will occur during November, 1994.

2. Contact

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3. Agencies Involved

Metro Toronto and Region Remedial Action Plan
Ontario Ministry of Environment and Energy, 7 Overlea Blvd., 4th Floor,
Toronto, Ontario M4A 1AH

4. Restoration Goal

Increase structural complexity within sheltered Toronto waterfront habitats, thereby reducing the extent of aquatic habitat impairment caused by shoreline alteration.

5. Project Type

Placement of woody brush and fallen trees at sheltered warmwater sites, i.e., embayments and river mouths.

6. Background and Rationale

Aquatic habitats at the Metro Toronto waterfront have been degraded by physical alterations such as lakefilling, dredging, erosion control, and parks landscaping and maintenance. These activities have resulted in increasingly simplified littoral zones within the Toronto AOC. Addition of structure to relatively featureless warmwater habitats may increase fish production (Pardue 1973; Vogele and Rainwater 1975; Wege and Anderson 1979) and help restore natural productive capacity to the waterfront.

Sheltered warmwater habitats across the waterfront historically included wood debris deposited by river flow and shoreline erosion. Within the present urban setting, existing land and water uses (e.g., parks, marinas) may preclude larger-scale habitat restoration projects at some sites. Trees and brush continue to be cleared within the Toronto area for the purposes of urban development. Re-use of these materials may offer an inexpensive and feasible opportunity to improve habitat where natural structure is absent.

Placement of brush shelters and fallen trees at critical sites can provide cover for various biota, as well as attachment substrate for growth of periphyton and associated grazing organisms (invertebrates). Increased biological production at warmwater sites should result from greater structural complexity within existing littoral zones. Underwater woody structure may enhance spawning, nursery and feeding habitat for native fishes. Additional above-water habitat may be created for terrestrial and amphibious wildlife. Brush shelters have also been documented to improve colonization of aquatic vegetation at the placement site (Thomas and Bromley 1968).

Brush shelters and fallen trees will be located at sites defined by pre-project site assessment and fish community monitoring. Structure placement will be carried out during late fall, 1994.

7. Regulatory Considerations

This project followed the procedures for "Class Environmental Assesment For Small-Scale MNR Projects" as a Category "C" project having little or no detrimental effect on the environment. The environmental assessment for this project complied with the Environmental Assessment and Review Process Guidelines Order which sets out the Federal Environmental Assessment Review process. Authorization to proceed with the project was obtained from the Canadian Coast Guard, with compliance to requirements of navigation safety and the public right of navigation. The project was reviewed and endorsed by the Metro Toronto RAP coordinator representing the RAP Public Advisory Committee, as well as municipal representatives.

8. Criteria

Brush shelters and fallen trees will be located at sheltered sites tending towards warmwater conditions, and where cover and structure are lacking due to shoreline alteration. Depth of location will be defined by on-site conditions. Shallow placement with significant above-water structure may be carried out in turbid waters with high sedimentation rates. More transparent conditions may result in shelters being located at greater depth (3-5 m below minimum lake level). A minimum navigational depth of 2.4 m may be required near areas of boat activity. Initial structures will be deployed on an experimental basis and will be removable if necessary.

9. Project Design

Tree species selected to increase structural complexity of aquatic habitat should provide long-lasting underwater structure. Hardwood species such as maple, oak, and beech are relatively durable under sheltered conditions (Thomas et al. 1968). Cedar may also be used. Brush shelters will consist of bundled units wired together and weighted to minimize the possibility of dispersal by wave action. Brush bundles will form units easily managed by two people. Large-diameter tree limbs (diameter greater than 10 cm) will not be included in brush bundles/shelters to minimize the possibility of any damage to boats. Fallen trees will be chained to an appropriate anchor point at shore. Deeper water brush shelters may perform a "reef" function and be more extensively wired and weighted with concrete blocks. The shelters will be linear in shape, run parallel to shore, and will be located within the euphotic zone to allow periphyton to colonize surfaces.

10. Implementation

Implementation of this project was completed during the winter of 1994/1995. Suitable trees and brush were obtained from various land clearing activities related to property development within the Metro Toronto area. On-site work consisted of placement of 55 weighted brush shelters (primarily white cedar) at the 3-m depth contour within a lake embayment of Humber Bay Park East. These were released from a boat at the appropriate depth.

Twenty-one fallen logs and tree crowns (white cedar and red pine) were placed between high and low lake water levels within a created coastal wetland at Colonel Samuel Smith Park. The logs and crowns were placed to provide available above-water and shallow-water structure at all lake level conditions. Tree crowns and logs were dragged over the ice to an appropriate anchor point, then left to settle to the wetland bottom during the spring thaw.

11. Degree of Environmental Intervention

Linear scale of brush shelter size will be in the order of several dozens of metres. No adverse environmental impacts are expected from this project, as woody materials exist naturally at sheltered littoral zones within the Great Lakes basin. These structures will not eliminate any existing habitat and are intended to restore natural complexity to shorelines previously degraded and simplified.

12. Cost

Projected cost of construction of two linear brush shelters during the initial pilot year will be 25 K.

13. Biological Assessment

Pre-project characterization at prospective sites consists of littoral habitat description and mapping, as well as evaluation of on-site fish communities and other biota. Similar post-project data collection will be carried out during 1995 and used to quantify "net gain" of productive capacity.

14. Measures of Success

Post-project indicators of increased productive capacity resulting from the created habitat include the following

- increased levels of primary production (periphyton) occurring at the project site;
- increased biomass of forage organisms (invertebrates) present on underwater structure;
- increased numbers and biomass of forage fish occurring in the vicinity of the brush shelter;
- increased numbers of young-of-the-year and juvenile sport fish present in the vicinity of the brush shelter;
- improved colonization of macrophytes at the project site;
- use of above-water brush structure by terrestrial and amphibious biota;
- ability of the brush shelter to maintain structural and functional integrity for 15-25 years.

Success Rating: 1 (assessment incomplete).

15. Key References

Pardue, G.P. 1973. Production response of the bluegill sunfish, *Lepomis macrochirus* Rafinesque, to added attachment surface for fish-food organisms. Trans. Amer. Fish. Soc. 102: 622-626.

Thomas, P.M., and Bromley, D.D. 1968. The establishment of aquatic vegetation in and around artificial fish shelters in Douglas Lake, Michigan. Amer. Midl. Nat. 80(2): 550-554.

Thomas, P.M., LeGault, R.O., and Carpenter, G.F. 1968. Durability and efficiency of brush shelters installed in 1937 in Douglas Lake, Michigan. J. Wildl. Manage. 32(3): 515-520.

Vogele, L.E., and Rainwater, W.C. 1975. Use of brush shelters as cover by spawning black basses (*Micropterus*) in Bull Shoals Reservoir. Trans. Amer. Fish. Soc. 1975(2): 264-269.

Wege, J.G., and Anderson, R.O. 1979. Influence of artificial structures on largemouth bass and bluegills in small ponds. *In* D.L. Johnson and R.A. Stein [*editors*]. Response of fish to habitat structure in standing water. N. Cent. Div. Amer. Fish. Soc. Spec. Publ.6.

Correct citation for this contribution:

Strus, R. 1995. Metro Toronto Waterfront - restoration of natural habitat structure, p. 55–58. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 9

1. **Project Title: Mitigation of Low pH in Salmonid Streams**

2. **Contact**

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3. **Agencies Involved**

Department of Fisheries and Oceans
Nova Scotia Department of Fisheries

4. **Restoration Goal**

Increase stream and interstitial water pH to protect fish at times of acidic episodes.

5. **Project Type**

Addition of limestone gravel to the bed of a section of a small acidified brook to form bars for water contact and percolation to increase pH and mitigate low pH effects on fish.

6. **Background and Rationale**

Fifteen Mile Brook, Nova Scotia, a tributary of the Medway River, is regularly used by Atlantic salmon and brook trout for spawning and provides nursery habitat for these species. However, as a result of annual acidic episodes that occur in autumn lasting through the winter, juvenile salmon rarely survived to be yearlings. Brook trout did survive, but were stressed physiologically by the low pH.

In September 1987, the lower section of Fifteen Mile Brook was limed by adding crushed limestone to the bed of the brook in several areas. Limestone was again applied on a smaller scale in November 1991 to replenish some areas.

The intent was first to provide a better environment for egg, alevin and fry survival, and then to limit the lethal effects on juveniles during acidic episodes. In contrast to headwater lake liming, the application of limestone to stream beds is relatively inexpensive if road access is available and the limestone should not have to be replenished on an annual basis. The method was selected for its suitability for use in running waters in small streams with no headwater lakes that could be used for liming. However, the methodology had only been tested on several occasions and with limited success, and no long-term biological assessment had previously been done.

7. Regulatory Considerations

An Initial Environmental Assessment form, an internal review procedure, was completed prior to project initation. For other participants, habitat modification permits would be required.

8. Criteria

The stream selected for liming must be small with low water discharge; usually <1 m^3/s and, preferably, <10 m^3/s at times of peak flows. The amount and size of limestone required is a function of stream size and flow. However, effectiveness is ultimately related to water contact time with the limestone and water temperature. The bars selected for adding crushed limestone should be shallow and provide a large surface area for water contact and percolation through the gravel. The bars must also be located in channel sections where conditions and features lead to bar stability to prevent loss of the limestone downstream to pools where it loses contact with much of the flowing water, severely reducing its effectiveness.

The physical parameters of the stream sites are of key importance to the success of this type of limestone mitigation technique. The stability of the limestone bars is dependent on stream hydrology and the physical characteristics of the channel and stream bed. Straight, shallow and evenly-based stream sections are the most stable sites for successful gravel application. Winding, deep, or unevenly-based sections prove to be unstable for treatment.

Limestone gravel is best applied during low flow periods in late summer. Sites should be assessed beforehand to assure stability and should be chosen according to the following guidelines: (a) The site should have a relatively level substrate of cobble, gravel, and boulders; (b) Sites should have a run or riffle morphology; (c) A site may have a pool located upstream, but no pool immediately downstream; and (d) The site should not have sharp turns or bends in the stream bed, especially if the site is less than 15 m wide.

9. Project Design

The lower 800 m of Fifteen Mile Brook to the mouth of the brook were used as an experimental area. The brook enters the Medway River which is located on the southwest coast of Nova Scotia. A control section of 250 m, farthest upstream, was left unlimed and undisturbed. A 300 m section of the brook, downstream of the control section was limed by adding crushed limestone to 8 bars across the brook at 25-75 m intervals. This was done to avoid creating a barrier on one location at low flow, to modify existing spawning habitat, and to establish a longitudinal pH gradient. A section of 250 m, downstream of the last limestone bar and extending to the mouth of the brook, was left undisturbed.

The limestone bars were positioned at the downstream end of pools and at the head of riffles or in runs to simulate what is considered to be preferred spawning habitat characteristics for salmonids. The bars were shaped to create minimal disturbance to channel characteristics, water depth, and stream flow routing. The depth of crushed limestone added was also limited to ensure that the bars did not impede migratory fish movement.

10. Implementation

Approximately 200 tonnes of crushed, graded dolomitic limestone were added to the bed of Fifteen Mile Brook in 1987 and an additional 100 tonnes were added in 1991. The 4 cm grade "Fluxstone" limestone was delivered to several sites along the brook by the Moser Limestone Co. Ltd. of Upper Musquodoboit, Nova Scotia. The limestone was initially distributed over eight separate areas using light machinery to form bars 30-50 cm deep across the brook. The second limestone application supplemented 4 of these bars. The limestone was moved with a small front-end loader (approximately 2 m^3 bucket) to the desired location for application using several entry points along the stream. The machinery was driven along exposed sections of stream bed at times of extremely low water flows. After dumping, the limestone was spread and leveled by dragging the bucket in an upstream direction. Some further spreading and shaping of the bars was done manually using rakes to achieve the desired stream bed morphology and flow characteristics preferred by salmonids for spawning.

The amount of limestone initially added to form each bar ranged from 7.5 to 15 m^3 (16.7 - 33.5 tonnes). The amount added to four of the bars on the second application was about the same as that initially spread on each of these bars. Throughout the procedure, care was taken to avoid pools and to minimize disturbances instream to habitat adjacent to the limed areas and to stream banks.

11. Degree of Environmental Intervention

This liming methodology involves the application of gravel of foreign origin, dolomitic limestone, to the stream bed. This resulted in changes in water chemistry parameters such as pH, alkalinity, calcium, and magnesium. It also resulted in changes in morphometry, microhabitat water velocities, and bed material characteristics in treated sections. Application was done with small machinery and manually, and involved minimal disturbance to habitat in and along the stream when done at times of low water flow in late summer. No spawning fish were present in the stream at that time, and young-of-the-year had already moved to deeper habitat than the shallow areas used for limestone application. They would, therefore, not have been directly affected by physical disturbance associated with application of the limestone or modification of microhabitat in those areas.

For several days after initial application of the limestone, the water turned milky because of rinsing of limestone dust from the crushed material. Water turbidity and pH increased markedly. This condition was repeated at the time of the first major increase in stream flow when areas of exposed limestone were submerged for the first time and remaining fines were washed out of the limestone. However, no significant adverse effects on biota were detected as a result of this flushing. Some *in situ* bioassays with juvenile Atlantic salmon and brook trout were conducted during one such flushing episode. The application of limestone gravel to the stream bed only needs to be repeated infrequently; it is a relatively long-lasting substance which dissolves according to temperature and flow. This is in contrast to methods using a limestone slurry addition to the stream or the application of powdered lime to headwater lakes which require frequent intervention. Therefore, the approach used minimizes the impact and degree of environmental intervention directly associated with liming for mitigation of low pH.

12. Cost

1987	Limestone (200 tonnes)	$1 100
	Trucking	$2 926
	Application	$1 000
	Total	**$5 026**
1991	Limestone (100 tonnes) and trucking	$2 000
	Application	$2 500
	Total	**$4 500**

NOTE: Costs of chemical and biological assessments are not included.

13. Biological Assessment

An assessment of the impact of limestone application on water chemistry and on fish populations in the brook was conducted over 8 years. This assessment involved comparisons of limed and unlimed sections of the brook. Water chemistry was monitored on a weekly to monthly basis in both sections, and periodically at sites along the brook. Stream discharge was monitored weekly and water temperature was recorded continuously. Interstitial conditions in the stream bed also were monitored in both sections over several winters.

The density of all fish species present in both sections of the brook was estimated twice annually using the sequential-removal method, and their biomass was determined separately by age-class. Counts of Atlantic salmon spawning redds were made annually in both sections of the brook. The emergence success of Atlantic salmon and brook trout alevins was assessed on several occasions. Microhabitat use by brook trout and juvenile Atlantic salmon was also examined over two years in response to acidic episodes and the longitudinal pH gradient related to liming, and in relation to changes in available microhabitat as a result of limestone application. *In situ* bioassays to assess the survival of juvenile Atlantic salmon and brook trout were also conducted over three years in limed and unlimed sections of the brook during acidic episodes in autumn and spring. These bioassays were complemented with detailed measurements of the physiological responses of the fish to chemical conditions in each section of the brook.

14. Measures of Success

The following could serve as indicators or measures of some degree of success of the application of limestone to the stream bed to mitigate low pH in a section of stream:

- increase in stream and interstitial water pH and associated chemical parameters;
- intensive use of limestone bars for redd digging and spawning by salmon;
- increased survival of salmon and brook trout eggs, alevins, and fry;
- survival of age-0 Atlantic salmon past the acidic episodes in autumn;
- decreased physiological stress for brook trout and juvenile salmon;
- increased density and biomass of all age classes of juvenile salmon and brook trout;
- stability of microhabitat use by juvenile salmon and brook trout along the limed section;
- recolonization by other fish species sensitive to low pH and their survival.

Success Rating: 4

Some degree of chemical and biological success was evident but with gradual return towards pre treatment conditions over an 8-year period.

15. Key References

Lacroix, G. L. 1992. Mitigation of low stream pH and its effects on salmonids. Environ. Pollut. 78: 157-164.

Lacroix, G. L. 1995. Stability of microhabitat use by brook trout and juvenile Atlantic salmon after stream acidification. Trans. Amer. Fish. Soc. (in press)

Mayhew, H. 1989. The effects of limestone gravel application to two acidic Nova Scotian streams. N.S. Dep. Fish., Econ. Reg. Dev., Agreement Rep. No. 22, Pictou, N.S.

Correct citation for this contribution:

Lacroix, G.L. 1995. Mitigation of low pH in salmonid streams, p. 59–63. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 10

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1. Project Title: Lower Don River Demonstration Wetland Habitat

2. Contact

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Task Force To Bring Back The Don, Toronto City Hall, 20th Floor, East Tower, Toronto, Ontario
M5H 2N2
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3. Agencies Involved

Other members of the project's Implementation Steering Committee will be:
City of Toronto Departments
Public Works and the Environment
Planning and Development
Metropolitan Toronto Parks and Property Department
Metropolitan Toronto and Region Conservation Authority

4. Restoration Goal

To create a viable wetland habitat in the Lower Don Valley.

5. Project Type

Modification of existing landform, creation of ponds, and planting of native wetland plant species.

6. Background and Rationale

The Don is one of Toronto's largest and most significant open spaces. Its restoration is key to creating a more livable city. Wetlands were once a common feature in the Don. The creation of new wetlands in degraded areas of the river valley is key to restoring the Don.

The wetland habitat that the Task Force to Bring Back the Don is planning will provide much needed habitat for birds and animals. We expect that the wetland also will serve a much needed educational function giving Toronto residents opportunity to learn about the essential roles of wetlands and naturalized landscapes. The wetland may also provide some water quality benefits.

The wetland will be consistent with evolving plans for the Don by:

- the Waterfront Regeneration Trust's Lower Don Lands Strategy team;
- the MTRCA's Don Watershed Task Force;
- the Metro Parks and Property Department.

Implementation of the project will begin in the early spring of 1995.

7. Regulatory Considerations

Approval from the following agencies was required:

a) Ontario Ministry of the Environment and Energy
b) Ontario Ministry of Natural Resources
c) local conservation authority - Metro Toronto Regional Conservation Authority
d) City of Toronto
e) Metro Toronto

8. Criteria

The wetland has been designed so as to attract three target species:

1. Wood duck
2. Northern pike
3. Bull frog

The design phase of the project involved a comprehensive public consultation process. The target species, site selection, and final design emerged as a result of this public process.

9. Project Design

The design phase of the project has identified a site for the wetland that is just south of the Bloor Street viaduct. The wetland area is approximately 2.88 ha in size. The consulting team, led by Glenn Harrington of Harrington and Hoyle Limited, has proposed a wetland with a variety of habitats including wet meadow, wet woods, and marsh. There will also be related upland forest habitat created and bank stabilization work done. The wetland will feature two distinct areas - one on the east side of the Don and one on the west. The area on the west side will be protected, providing excellent habitat. The area on the east side will be accessible to the public; it will provide for education and viewing opportunities. The wetland is expected to attract wood ducks, red-tailed hawks, salamanders, and wood frogs. The wetland will be adjacent to the river but will not receive direct flow except during flood events.

10. Implementation

The consulting team is in the process of completing final construction drawings for agency review and approvals. All approvals, from regulatory and land owning agencies such as the Metropolitan Toronto and Region Conservation Authority and Metro Parks and Property, are expected by the end of 1994.

All grading and heavy construction will start in March of 1995. Planting will start in April and May of 1995. In the spring planting season we will concentrate on trees and shrubs as well as foundation aquatic plants including bulrushes and cattails which will help stabilize the wetland and protect against unwanted invasive species. Bank stabilization along the related portion of the main channel of the Don will also commence in April and May 1995. Throughout the summer of 1995, we will mantain and monitor the site. The proposed trails system with a mix of paths and board walks and educational signage will be completed in 1995. Planting will resume in the spring of 1996 when the focus will be on increasing ecosystem diversity with an extensive collection of aquatic plants. Throughout the summer of 1996, we will again mantain and monitor the site.

Some of the construction and maintenance and monitoring will be undertaken by volunteers who have been involved with the Bring Back the Don project and by members of the general public who will be encouraged to become involved in our communications materials.

The Task Force will be developing a plan for maintenance and monitoring. The plan will provide for maintenance plantings over the first years of the life of the wetland. Volunteers will plant each spring and fall to increase ecosystem diversity. The emphasis over the maintenance period will be on using harvested seeds and cuttings for replanting. The plan will also provide for monitoring of target species (such as amphibians) as well as water quality. Any decisions about the maintenance and monitoring of the wetland beyond the first years will be made in the future by the land managing agency, Metro Parks and Property, in consultation with the other affected agencies.

A portion of the wetland site is an old landfill area. The soil in this landfill area contains old garbage and ash; the restoration of this kind of area will provide lessons for rehabilitating similar kinds of areas.

11. Degree of Environmental Intervention

The project will involve extensive intervention with respect to the environment during the initial spring 1995 construction period; bulldozers, tractors and trucks will be utilized. Once the initial construction period is over, during planting, maintenance and monitoring, intervenion will be kept to a minimum. Measures, such as sediment control measures, will be taken to minimize any impact on the environment. The degree of environmental intervention can be justified because the site is so degraded and because it supports so little wildlife at present.

12. Costs

The budget for the design phase was $40 ,000 for site selection, design, and agency approvals (everything up to "shovel in the ground"). The design phase was funded by a number of public and private sources including the Great Lakes Cleanup Fund and Canada Trust's Friends of the Environment Foundation.

The estimated implementation budget for the project is $360 ,000. For:
Construction Contracting and Materials
Professional Fees
Path System and Signage
Maintenance
Monitoring
Volunteer Management
Communications

The implementation phase of the project will be funded by the Great Lakes Cleanup Fund and the Canada-Ontario Infrastructure Program.

13. Biological Assessment

We are now undertaking a baseline inventory. We will monitor during construction and for a number of years after the project has been completed.

14. Measures of Success

We will measure success by attempting to gauge:

1. The extent to which the target species have been attracted;
2. The extent to which other species have been attracted;
3. Public interest in the wetland;
4. The success of our public involvement and education programs.

Success Rating: 1

15. Key References

Bringing Back the Don, Task Force to Bring Back the Don, Toronto, Ontario, 1991.
Regeneration, The Royal Commission on the Future of the Toronto Waterfront, Toronto, Ontario, 1992.

Correct citation for this contribution:

Stonehouse, D. 1995. Lower Don River demonstration wetland habitat, p. 64–68. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 11

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1. **Project Title: Creating Upwellings as Habitat for Incubation of Eyed Stage Brook Trout (*Salvelinus fontinalis*) Eggs**

2. **Contact**

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   Tel.: (715) 682-6185; FAX: (715) 682-8499

3. **Agencies Involved**

   Grand Portage and Red Cliff Bands of Lake Superior Chippewa

4. **Restoration Goal**

   Create spawning habitat capable of incubating eyed brook trout eggs to hatch and emergence.

5. **Project Type**

   Reintroduction of an extirpated stock of brook trout (Lake Superior "coaster").

6. **Background and Rationale**

   Anadromous runs of large brook trout (locally called "coasters") were once common and widespread in Lake Superior and its tributaries (Smith and Moyle 1944). Highly prized by anglers and sensitive to habitat perturbations, coaster populations were decimated by 1900. Currently, only a few remnant stocks are known to exist in the Lake Superior basin.

   At the request of, and in cooperation with the Grand Portage and Red Cliff Bands of Lake Superior Chippewa, the USFWS initiated experimental management projects directed toward restoration of coaster brook trout in parts of Lake Superior from which they were extirpated.

   Attempts have been made since the early 1900's to restore Lake Superior coaster populations by stocking hatchery fish (Smith and Moyle 1944). Those attempts have produced very low returns and provided no evidence of reproduction. Speculation is that the lack of success was caused by the use of an inappropriate strain of brook trout, lack of "wild" fitness of hatchery fish, or failure of hatchery fish to properly imprint homing instincts.

We used the most closely linked genetic population available (the Nipigon strain) for the restoration efforts, and we used the earliest life stage possible (eyed egg) to maximize imprinting and synchronization with natural food supplies.

Brook trout preference for spawning on springs or upwellings has been widely reported (Raleigh 1982). We attempted to locate the type of habitats where native populations might have spawned originally, then use or create upwellings simulating typical brook trout spawning habitat. We also created redds without upwelling flows to provide a comparison. We then introduced eyed Nipigon strain brook trout eggs into the substrate and monitored the hatch rates by placing egg incubators in with the eggs. We did not attempt to quantify fry emergence. Egg introductions were begun in Grand Portage streams in January 1992, and in Lake Superior (Red Cliff Reservation) in January 1994.

7. Regulatory Considerations

As this cooperative project took place on Tribal lands, no permits were required.

8. Criteria

Brook trout are known to spawn in a variety of riverine and lentic habitats (Raleigh 1982). Other sources suggest that brook trout may reproduce in streams where upwellings are not present (Hale and Hilden 1969).

Habitat usually includes:
- areas of ground water upwelling;
- gravel, rock, and sand substrate;
- minimal amounts of silt or fine sediment;
- temperatures from 4.5 to 10°C.

9. Project Design

Using native substrates, we constructed artificial spawning redds in three distinct environments; a stream with no apparent groundwater nearby, a stream at its groundwater source and a nearshore, shoal area of Lake Superior where groundwater seepage occurred just above the waterline. In Lake Superior we raked together gravel and stone that occurred in about 0.4 m depth to form a redd about 1 m wide and 0.2 m deep. In both of the streams, we created the same type of redds, but in two sites we also created upwelling through the substrate by installing PVC pipe underneath and upstream to provide a gravity feed.

10. Implementation

Eyed Nipigon strain brook trout eggs were provided for this project by the Ontario Ministry of Natural Resources from the Dorion Fish Culture Station. Eggs from this source reach eyed stage around January 1.

Artificial redds were prepared on chosen sites within one day before the arrival of the eggs. In all sites the substrate consisted of coarse sand, gravel and small rock.

Eggs were implanted in the created redds by inserting a 1.3 m length of 5.1 cm diameter PVC pipe into the bed to a depth of 5-10 cm and pouring eggs and water down the pipe. Eggs were inserted in this manner in several spots in each redd (Gustafson-Marjanen and Moring 1984). Egg incubators containing a known number of eggs were placed in each redd along with the eggs, as a means of evaluating hatch rate.

We projected an approximate hatch date for each site based on the actual thermal units that eggs were subjected to. We removed incubators within one week following the projected hatch date. Hatch rate was determined as the number of living fry found in an incubator divided by the total number of eggs placed in the incubator.

11. Degree of Environmental Intervention

Primarily, microhabitats in the substrate disturbed were affected. On site disturbance was limited to an area of less than 2 m^2 for each site. Hand tools (shovel and rake) were used to make modifications. As silt was limited in the chosen sites, little siltation occurred.

12. Cost

Labor and Materials	$120
Biological Assessment	$ 80
	$200

13. Biological Assessment

Evaluation of hatch success in incubators. Survey of streams and nearshore Lake Superior in stocked areas to confirm presence of year-classes of brook trout. As trout mature, sites will be monitored for return of spawning adults.

14. Measures of Success

If brook trout fry can be successfully and inexpensively produced in artificial or improved habitats, the technique may have applicability for reintroducing extirpated populations. We would expect that fry produced by direct stocking of eyed eggs should exhibit more "wild" characteristics and be more likely to establish reproducing populations than stocked hatchery fish.

Evaluation of hatch rate in incubators showed high survival to fry stage (84-93%) in all sites except where the redd was improperly placed and dewatering and freezing occurred. No attempt was made to verify the comparability of hatch rates in the incubators with that of the eggs in surrounding substrate. However, from the low number of dead eggs observed in the redds and the numerous fry we observed in the areas of the redds when incubators were retrieved, we suspect that hatch rates may have been similar.

The high hatch rates observed here, both where upwellings were used and where they were not, suggest that this technique might have advantages in cost and quality of the fish produced as compared to the use of Vibert Boxes for hatching, or by the use of hatchery fingerlings.

Success Rating: 4

but unknown at this time whether fish produced will survive and establish a naturally reproducing population. Also unknown whether adults will return and spawn on created redds.

15. Key References

Gustafson-Marjanen, K.I., and Moring, J.R. 1984. SFA 30(1) Construction of artificial redds for evaluating survival of Atlantic salmon eggs and alevins. Amer. J. Fish Manage. 4(4A): 455-461.

Raleigh, R.F. 1982. Habitat suitability index models: Brook trout. U.S. Dept. Int., Fish Wildl. Serv. FWS/OBS-82/10.24: 42p.

Smith, L.L., and Moyle, J.B. 1944. A biological survey and fishery management plan for the streams of the Lake Superior north shore watershed. Minn. Dep. Conserv., Div. Game Fish. Tech. Bull. No. 1.

Correct citation for this contribution:

Newman, L.E. 1995. Creating upwellings as habitat for incubation of eyed stage brook trout (*Salvelinus fontinalis*) eggs, p. 69–72. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 12

1. **Project Title: Transplanting Aquatic Vegetation in Collingwood Harbour**

2. **Contact**

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Collingwood Harbour Remedial Action Plan (RAP), 275 First St., Unit #6,
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Tel.: (705) 446-0551; FAX: (705) 446-0561

3. **Agencies Involved**

Nottawasaga Valley Conservation Authority (NVCA), RR 1, Angus, Ontario L0M 1B0
Ministry of the Environment and Energy, 40 St. Clair Ave. West, Toronto, Ontario M4V 1M2
Ministry of Natural Resources, Lake Huron Assessment Unit, 611 9th Ave. East, Owen Sound, Ontario N4K 3E4
Ministry of Natural Resources, District Office, Midhurst, Ontario
Brian McHattie, Canadian Wildlife Service (CWS), 73 Mt. Pleasant Ave., Dundas, Ontario

4. **Restoration Goal**

To increase the biotic integrity of the Collingwood Harbour fish and wildlife populations, by rehabilitating the existing wetland complex, and by the creation of additional wetland habitat.

5. **Project Type**

a) Re-establishing extirpated aquatic vegetation in areas degraded by poor water quality and carp activities.
b) Creating spawning and rearing habitats for northern pike (*Esox lucius*) and other fish species.
c) Increasing shoreline diversity for aquatic organisms.

6. **Background and Rationale**

In 1972 the International Joint Commission identified Collingwood Harbour as an Area of Concern (AOC). Historically, most of the Harbour suffered from the stress of development, and other negative effects associated with ship building activities. Currently, excessive suspended solids loading and nutrient enrichment are two significant factors which have had negative effects upon the quality of the Harbour waters. As a result, there has been a severe reduction in the size and diversity of wetland areas within the Harbour.

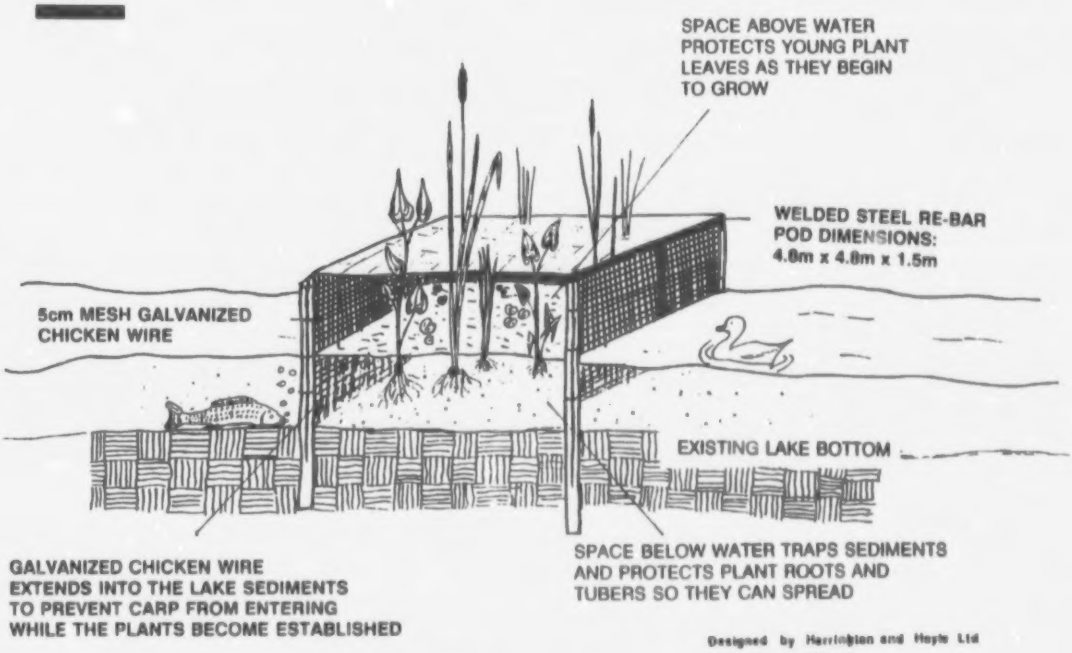
The Collingwood Harbour Remedial Action Plan (RAP) and its Public Advisory Committee have identified several rehabilitation strategies. The first strategy involved the development of five wetland "pods" (Figure 1), which are all located within the Harbour. The locations for the "pods" was based on the following parameters:

a) Acceptability by the Canadian Coast Guard under the Navigable Waters Protection Act. Because Collingwood Harbour is heavily used by recreational boaters, nearly 75% of the harbour was marked as "off limits to structures that may inhibit navigation of boats".
b) Historically, these areas had an abundance and diversity of aquatic emergent vegetation.

By constructing the "pods" at various depths, these areas will be revitalized of aquatic emergent vegetation. While these plants are not available to adult fish, they do provide the necessary refugia required by young-of-the-year (YOY) smallmouth bass and other aquatic invertebrates. As a result, the "pods" will protect vegetation, especially from carp grazing activities and spawning.

The second strategy is the creation of northern pike channels in the wetland. The purpose of these channels is to:

Wetland Exclosure Pod


SPACE ABOVE WATER PROTECTS YOUNG PLANT LEAVES AS THEY BEGIN TO GROW
WELDED STEEL RE-BAR POD DIMENSIONS: 4.8m x 4.8m x 1.5m
5cm MESH GALVANIZED CHICKEN WIRE
EXISTING LAKE BOTTOM
GALVANIZED CHICKEN WIRE EXTENDS INTO THE LAKE SEDIMENTS TO PREVENT CARP FROM ENTERING WHILE THE PLANTS BECOME ESTABLISHED
SPACE BELOW WATER TRAPS SEDIMENTS AND PROTECTS PLANT ROOTS AND TUBERS SO THEY CAN SPREAD

Designed by Harrington and Hoyle Ltd
Landscape Architects

Figure 1

a) allow water to enter the wetland which was drying partly because of the invasion of purple loosestrife;
b) provide pike with an access to suitable areas for spawning;
c) create shoreline diversity for fish and wildlife.

7. Regulatory Considerations

Permits are not usually required when transplanting wetland vegetation. Persons transplanting should have the permission of landowners, and should cause as little damage as possible to the landscape. Care should also be taken to avoid the introduction of species such as purple loosestrife into areas were they currently do not exist.

Because the wetland "pods" were placed in Collingwood Harbour, in areas that were accessible to watercraft, as extensive permit review process was required. The following is a summary of the permits required by the RAP to implement the project.

1. Navigable Waters Protection Act. An exemption from this act was granted by the Marine Navigation Services Branch. Because Collingwood Harbour is a federally regulated port, an exemption of permit was not required from the Department of Fisheries and Oceans (DFO), Small Crafts and Harbour Section.
2. Fisheries Act. DFO was consulted as the work sites were federally regulated. Authorization of this project pursuant to section 35 of the Fisheries Act was not required as no fish habitat was altered or destroyed.
3. Section 14, Public Lands Act. Authorization under this act was required from MNR Midhurst. MNR Midhurst also required proof of public/local landowner consultation. This was accomplished through input from the Collingwood Harbour Public Advisory Committee, and the Habitat Subcommettee. Both Committees had active representatives from the Collingwood Yacht Club, Anglers Association, local citizens, and the Collingwood Harbour Master.
4. Fill Quality Guidlines for Lakefilling in Ontario, OMOEE. The Ministry of Environment and Energy was consulted concerning the nature of materials used for all projects. No concern was expressed under the Lakefilling Guidelines. As far as the Environmental Assessment Act was concerned, Ontario Reegulation 205 8(2) (h), gives habitat projects an exemption.

8. Criteria

- Northern pike prefer to spawn in heavily vegetated areas in marshes and bays of larger lakes (Scott and Crossman 1973).
- The results from the 1993 Collingwood Harbour Habitat Assessment and Fish Inventory (Collis and Proud 1993; Ferguson 1986) indicated that a greater number of juvenile fish were captured in areas where an abundance of aquatic vegetation occurred.

9. Project Design

The wetland "pods" were constructed with re-bar welded together to form panels (1.5 × 2.4 m). Each "pod" required 12 panels which were wired together on site and enclosed with galvanized chicken wire. This resulted in a "pod" 4.8 m long 4.8 m wide. (Refer to Figure 1). Water depth at the "pod" site varied from 0.5 m to 1 m. Cattail (*Typha latifolia*), bulrush (*Scirpus validus*), water lilies (*Nymphaceae*), pickerel weed (*Pontederia cordata*), arrowhead (*Sagittaria latifolia*), and cabbage weed are examples of the types of aquatic vegetation planted within the "pods". The original concept of these "pods" was taken from a similar project implemented by the Hamilton Harbour RAP.

The galvanized wire has a mesh size of 5 cm which effectively prevents carp from disturbing the transplanted vegetation, yet still allows access to various juvenile fish species and cyprinids (minnows).

The northern pike channels are similar to the design used by Hamilton Harbour RAP for the Grindstone Creek Pike Spawning Project. The channels are 2-3 m wide and 0.75 m deep. Beaded pools, 5 m diameter and 1 m deep were incorporated into the channels which provide deep water refuge for juvenile pike. Beaded areas were planted with various aquatic emergent vegetation such as bur-reed (*Sparganium eurycarpum*), sedge (*Carex* sp.) water lilies, and bulrush (Klots 1966).

Each of the species that were planted in the "pods" and channels were chosen based on their merits as indicated below.

Arrowhead: Offers cover for juvenile fish. Dragonflies frequently visit the flowers while snails eat the petals.

Bulrush: Offers cover for juvenile fish. This plant is also important for nutrient uptake in nutrient enriched areas.

Bur-reed: Provides an excellent food source for water fowl and song birds.

Cabbage Weed: Offers cover for various juvenile and adult fish species

Cattail: Provide a rich food source for insects which in turn also provide birds with food. The roots and fresh shoots are eaten by muskrats.

Pickerel Weed: Offers cover for juvenile fish from predators such as the great blue heron and the tern.

Sedge: Provides northern pike with substrate for spawning. It is also and excellent food source for waterfowl.

Water Lily: Offers excellent cover from predators for juvenile fish as well as provide an important food supply for muskrats. The leaves are also used as basking platforms for amphibians.

Wild Rice: Provides habitat for adult and juvenile fish. It is also one of the most desirable food source for waterfowl.

10. Implementation

All of the vegetation that was planted within the "pods" and channels came in the form of transplants from various donor sites in the Collingwood area, with the exception of wild rice (*Zizania aquatica*). The majority of planting occurred during a 10-week period, starting in mid-June through to August, while plants were at their peak/healthiest.

Several methods were used in transplanting vegetation. The white water lily (*Nymphaea tuberosa*), yellow water lily (*Nuphar advena*), pickerel weed and arrowhead were moved by placing a section of the tuber (still attached to the leaves) and a portion of the donor site soil inside a small burlap bag. Three small cuts were made in the bag which would allow the roots to grow and spread into soil of the new site. The top of the bag was loosely tied with twine to prevent the soil and tuber from escaping the bag before roots have been established.

During transportation, the leaves of the plants were kept moist and covered to prevent dehydration and ensure the health of the plant. Once on site, the bags were placed on the lake bottom inside the "pod" or in beaded area of the pike channel.

The following is a list of advantages for this method:

a) The indigenous soil provides the plant with the organic material to ensure its health and increase transplanting success.
b) The soil also helps to weigh down the tuber to help establish roots at the new site.
c) The burlap sack prevents animals, such as muskrats from eating the tubers before the plants have had a chance to reestablish themselves.
d) The weight of the sack (soil and tuber) facilitates the ease of planting since no digging is required.

Cattail, bur-reed, bulrush and sedge were planted by digging up the entire plant (roots, tuber, stem and leaves) and replanting it into the lake bottom. The sedge and bulrush were obtained by using a tool that is similar to a golf course cup cutter. Designed by J. Collis and constructed with re-bar, the cutter has a long handle attached to a barrel-like cylinder which has a sharp edge. (Refer to Figure 2). The edge is driven into the soil and pushed down to obtain as much root mass as possible. When the cutter is lifted out of the soil, a plug containing the soil, roots and stem of the plant remains in the barrel. With a gentle tug, the plug is removed from the barrel and placed on trays to be transported to the new site and replanted.

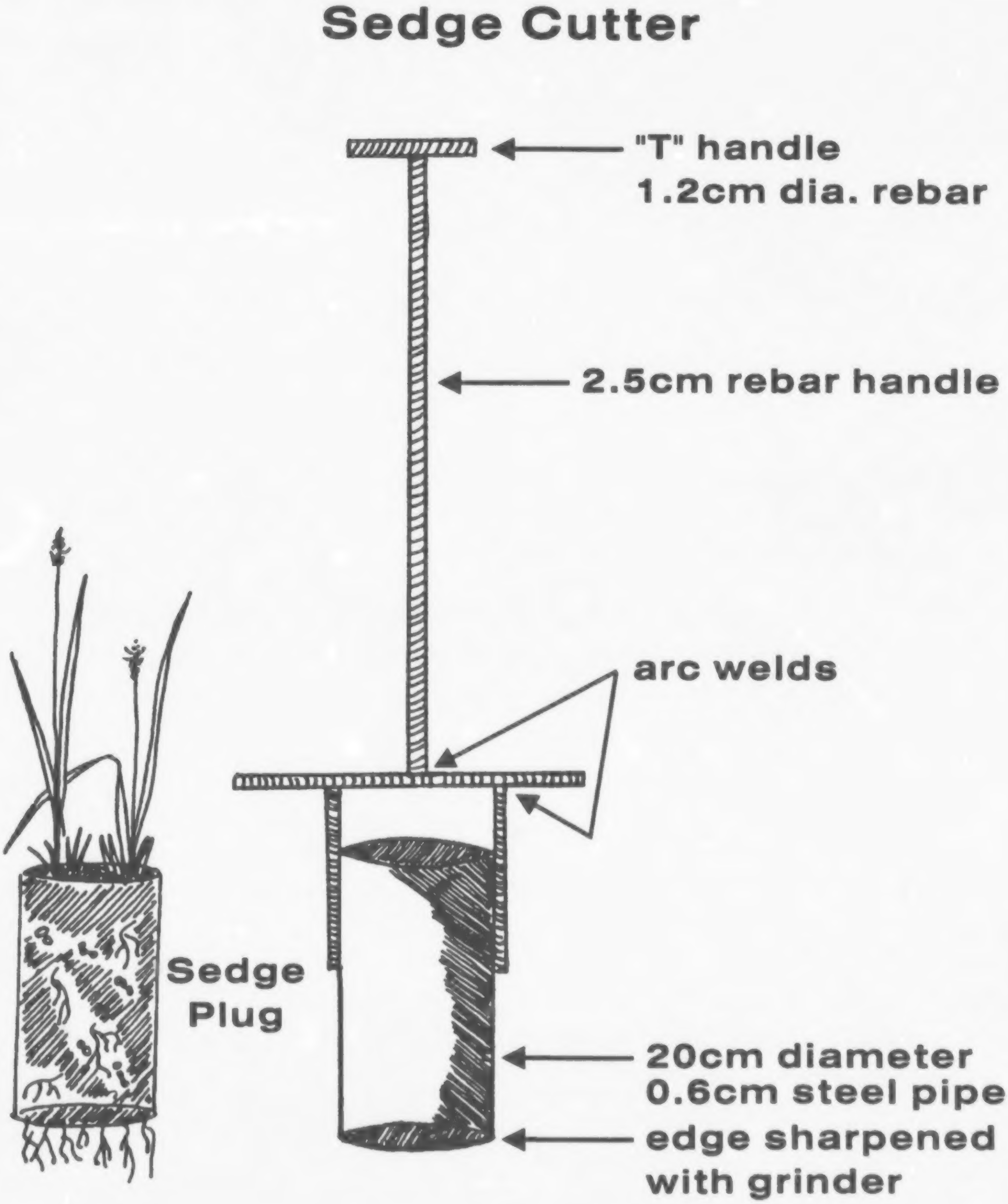

Sedge Cutter
"T" handle
1.2cm dia. rebar
2.5cm rebar handle
arc welds
Sedge
Plug
20cm diameter
0.6cm steel pipe
edge sharpened
with grinder

Figure 2.

Wild rice is extremely fragile and great care was taken during the collection and transplanting stage to minimize plant damage. The plants were collected by dragging a rake along the bottom of the lake. As the rake was dragged through the muck, the roots were loosened until the entire plant (stem and root) floated to the surface. The wild rice was then placed in a 95 L garbage can half filled with water for transport.

Since wild rice does not have a large root mass that can be easily replanted, the following method was devised. A piece of steel wire, approximately 10 cm long was coiled around the bottom of the stem (where the roots begin), while a 5-cm nail was coiled around the wire's free end. The entire length of the nail was then driven into the lake bottom, submerging the roots at the same time. The nail also acted as a weight to keep the plants from floating to the surface. Smaller plants would be clumped together so that two or three could be planted at the same time.

As stated at the beginning of this section, wild rice is also the only aquatic plant that has been seeded. Filter cloth was wrapped around the entire outside of the wetland "pod" (top to bottom), to prevent the seeds from drifting out of the enclosed area. The cloth also reduces the amount of wave action which will encourage germination. The seeds were scattered over the top of the "pod" to cover its entire surface. The seeds will float for some time before they sink to the bottom.

11. Degree of Environmental Intervention

The aquatic vegetation that was used to plant both the wetland "pods" and the northern pike channels are of the same genotype as existing vegetation and were obtained from local donor sites within the Collingwood area.

The donor sites experienced minimal negative impacts since they were chosen for their easy access and overabundance of desired plant species. These two factors prevent stock depletion and reduces disturbance to the plants remaining at the donor sites.

To reduce impacts during pike channel construction, the channels were dug in the winter when the ground was frozen and aquatic vegetation dormant. As a result, Collingwood Harbour Wetland experienced minimal impacts during pike channel construction. Ditch spoils were left on the sides of the channels which created amphibian and reptile habitats. During the removal of one ditch spoil in June, the most effected plant species was purple loosestrife. Since it is a nuisance plant, it was beneficial to rid a portion of the loosestrife from the wetland to allow the re-establishment of several aquatic vegetation species.

12. Cost

Labour:	$2 738.75
Materials:	$2 287.52
Equipment:	$1 950.00
Total:	**$6 976.27**

NOTE: To reduce costs, construction of the wetland "pods" was done in-house rather than tendered or contracted to a third party.

13. Biological Assessment

In 1993, Collingwood Harbour RAP completed an assessment of the Harbour which helped to determine the type and scope of rehabilitation projects. Existing aquatic and terrestrial vegetation, temperature profiles and turbidity readings are examples of the parameters used for this assessment.

Seine netting, larval fish trawls, trap netting, gill netting, smallmouth bass spawning surveys, and electrofishing were the methods used to determine the type of fish species which currently exist in the Harbour, their numbers, changes in frequency and optimum locations for spawning. This assessment provided baseline data which will help to determine the level of success for the various rehabilitation projects implemented this year and subsequent years.

It is the intention of the RAP to continue monitoring the rehabilitation projects within the Collingwood Harbour Wetland, particularly the wetland "pods" and pike channels using the methods mentioned above. Other methods include:

a) Visual Encounter Surveys (VES). Following the methodology outlined by Heyer et al. (1994), this is a survey that determines the species richness, compiles a species list, and estimates the relative abundance of amphibians and reptiles in the wetland.
b) Habitat Surveys to determine the type and number of avian species which inhabit and utilize the wetland.

14. Measures of Success

Because the habitat rehabilitation projects in the harbour have yet to complete their first full year, we do not have pre/post rehabilitation data sets. The success of the wetland "pods" and the pike channels will be determined next year through various monitoring techniques discussed in the previous section. If the plants have been able to reestablish themselves and can survive without the aid of the wetland "pod", the transplanting will prove successful, and can continue to further increase the amount of vegetation within the Harbour. The projects will also prove successful if there is a marked increase in the number of juvenile fish which have seen a decline in recent years, such as smallmouth bass, yellow perch, and northern pike. The number of spawning adults for the pike and bass species will also be indicators of success.

The success of shoreline diversity can be measured by the increase in the number of avian, amphibian, and reptile species which inhabit the Harbour area. This will ensure that the biotic integrity is indeed increasing and can improve with successive transplanting projects.

Success Rating: 1

15. Key References

Collingwood Harbour Remedial Action Plan Stage 2 Report: A Strategy for Restoring the Collingwood Harbour Ecosystem and Delisting Collingwood Harbour as an Area of Concern. 1992. Prepared by the Collingwood Harbour RAP team, in consultation with the Public Advisory Committee.

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Heyer W.R., Donnelly, M.A., McDiarmid, R.W., Hayek, L.C., and Foster, M.S. 1994. Measuring and Monitoring Biological Diversity - Standard Methods for Amphibians. ISBN 1-56098-284-5.

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Scott, W.B., and Crossman, E.J. 1973. Freshwater Fishes of Canada. Bull. Fish. Res. Board Can. 184.

Correct citation for this contribution:

Grillmayer, R. 1995. Transplanting aquatic vegetation in Collingwood Harbour, p. 73–81. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 13

1. Project Title: Soil Bioengineering for Streambank Protection and Fish Habitat Enhancement

2. Contact

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Collingwood Harbour Remedial Action Plan, 275 First Street, Unit 6,
Collingwood, Ontario L9Y 1C1
Tel.: (705) 446-0551; FAX: (705) 446-0561

3. Agencies Involved

Nottawasaga Valley Conservation Authority, R.R. #1, Angus, Ontario L0M 1B0
Ministry of Natural Resources, Midhurst, Ontario L0L 1X0

4. Restoration Goal

To repair and stabilize eroding streambanks through the use of vegetation, and to create instream cover by the construction of vegetated structures.

5. Project Type

Streambank stabilization, instream habitat creation, riparian enhancement.

6. Background and Rationale

The Black Ash Creek Project was initiated in 1992 as a component of the Collingwood Harbour Remedial Action Plan. The objectives of this project were to reduce sediment loading from the creek into the harbour and to enhance fish and wildlife habitat (Dobbs and Grillmayer 1994). Black Ash Creek contributes approximately 90% of the suspended sediment load for Collingwood Harbour (Collingwood Harbour RAP Stage 2 Document 1992). Sources of this sediment include erosion induced by cattle grazing steep escarpment areas, and eroding streambanks.

Soil bioengineering was chosen as a method of streambank stabilization for several reasons:

1. It is an applied science that combines structural, biological, and ecological concepts to construct living structures for erosion, sediment and flood control (Sotir and Gray 1989). Conventional methods of erosion and flood control (gabion, rip-rap, concrete vertical) provide little in habitat for terrestrial or aquatic organisms. These structures often have the effect of an

ecological barrier, separating aquatic and terrestrial. Because of the vegetation used in bioengineered structures, they tend to provide a wide range of habitat types for many organisms.

2. Bioengineered structures are labour intensive, not capital or energy intensive. Limited budget dollars was put into wages, not materials.
3. Because the structures are growing, they will require less long-term maintenance that conventional structures. Bioengineered structures also tend to be self-repairing.

This submission to the methods for habitat modification manual is based on the projects used on two sites: the Thompson Property (Site 1) and the Ferguson/Garbutt Property (Site 2).

Site 1

The erosion at this site was exacerbated by the channelization of the stream. The reduction of channel sinuosity, and the elimination of floodplain functioning had created an unstable reach of stream. Because the channel had been placed in a roadside ditch, the shoulder of the road (Conc. 10, Nottawasaga Twp.) was also eroding. A previous attempt to stabilize this channel with field stone failed because passersby on the road would remove this stone from the channel. Since the stream gradient was steep (3.1%) once the bed armour had been removed the streambed degraded, and this aggravated the eroding bank. The bank slope on both sides was near vertical.

Bank stabilization and streambed armouring took place during the fall of 1993.

Site 2

The stream channel on this property was heavily laden with debris. A large logjam had forced flood flows into a high sandy bank, eroding the soil and causing the bank to collapse. This collapse toppled large numbers of trees, which in turn increased the size of the logjam. Because of the debris and associated sediment deposition, the spawning and rearing habitat available to migratory rainbow trout was limited. The sediment and debris also had a negative impact on the other fish species present in Black Ash Creek.

Initial debris removal took place during the summer of 1992. Bank stabilization and habitat improvement works took place during the summer of 1992, and the spring of 1994.

7. Regulatory Considerations

a) Project was approved by the local Ministry of Natural Resources (Midhurst District), and a work permit issued under the Lakes and Rivers Improvement Act.
b) A permit from the Nottawasaga Valley Conservation Authority was required under Fill, Construction, and Alterations to Waterways Regulations.

8. Criteria

Site 1

The primary intent of this project was the stabilization of the eroding bank. Because the stream channel at this site is intermittent, habitats created were for the most part terrestrial. The desired stabilization technique would use vegetation as the primary support, rather than inert materials such as quarrystone or concrete.

Site 2

Rehabilitation efforts on this site were to achieve an increase in the population sizes of the fish species present in Black Ash Creek by creating a stable reach of stream characteristic of a typical 2nd or 3rd order stream. It was felt that, by achieving this goal, we would also partially reduce the amount of sediment contributed by that reach of stream to the harbour. Parameters that we decided upon for construction were:

1. re-exposing of rock/gravel substrates;
2. selective opening of the forest canopy to stimulate riparian and instream plant growth, without thermal loading;
3. use of vegetation and onsite materials for construction;
4. use of in-channel sediments both onsite and upstream to build-up intream structures;
5. where possible the use of native or naturalized plant species.

9. Project Design

Site 1

The confined nature of the channel prevented us from excavating a flood plain, or from sloping the banks to a stable angle. The east side of the channel was privately owned, and the owner was not open to the loss of property that would occur if regrading were employed. On the west side of the channel was the concession road, so regrading was also not an option. It was decided to construct a Bioengineered cribwall. This structure can be used to stabilize a vertical bank, and requires little room. The streambed was armoured to prevent down cutting. No attempt was made to stabilize the road shoulder.

A bioengineered cribwall is a hollow, interlocking arrangement of timbers, constructed as a wall (Figure 1). This structure is filled with suitable soil and layer of live branch cuttings. Once the cuttings have taken root and grown, they will eventually take over the structural functions of the timbers. The end result is a stable, vegetated slope.

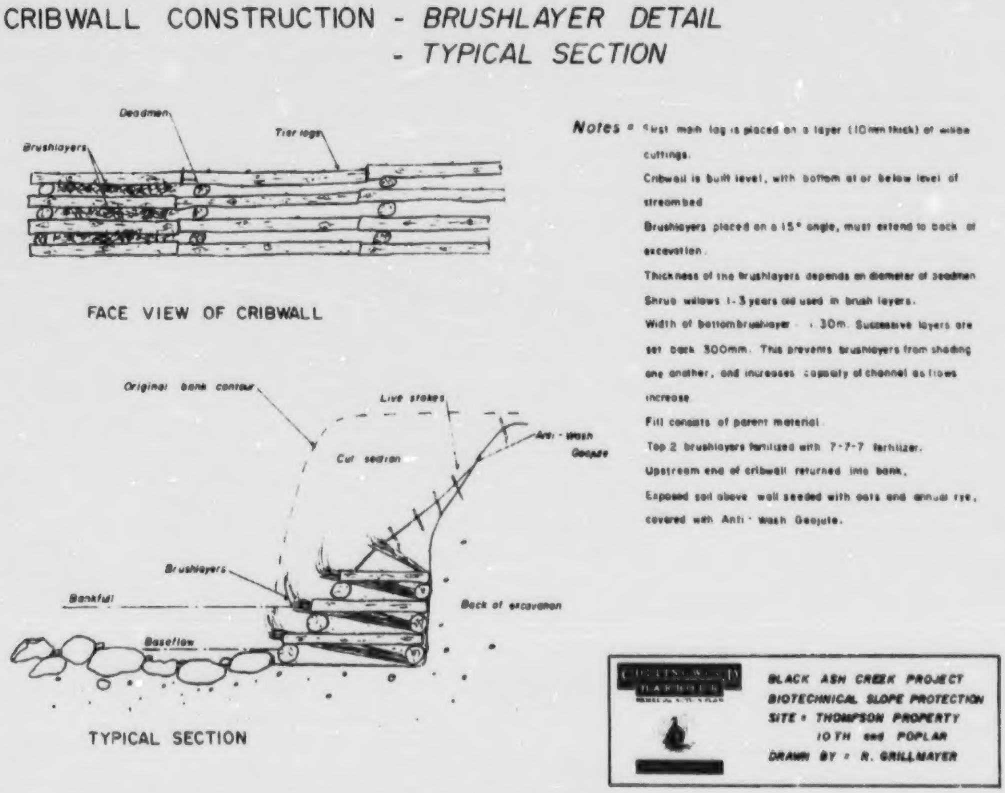
Site 2

We attempted to stabilize the bank by removing the instream debris, and by creating a low revetment wall at the base of the slope. The wall was built to a height well below the bankfull flow. This level was selected so flood flows could easily overtop the structure and enter the floodplain behind it. Spawning habitat would be reestablished were it was previously covered in debris. The eroding bank would be stabilized using bioengineered fascines, erosion control blankets, and seed mixtures.

A fascine is a long bundle of live cuttings bound together in a sausage-like structure. Fascines are effective in stabilizing slopes prone to shallow slides, and prevent the forming of shallow rills. They also are effective in stabilizing the toe of a stream bank.

10. Implementation

Site 1


CRIBWALL CONSTRUCTION - BRUSHLAYER DETAIL
- TYPICAL SECTION
Deadmen
Tier logs
Brushlayers
FACE VIEW OF CRIBWALL
Original bank contour
Live stakes
Anti - Wash Geojute
Cut section
Brushlayers
Bankfull
Baseflow
Back of excavation
TYPICAL SECTION
COLLINGWOOD HARBOUR
BLACK ASH CREEK PROJECT
BIOTECHNICAL SLOPE PROTECTION
SITE • THOMPSON PROPERTY
10TH and POPLAR
DRAWN BY • R. GRILLMAYER

Notes • First main log is placed on a layer (10mm thick) of willow cuttings.
Cribwall is built level, with bottom at or below level of streambed
Brushlayers placed on a 15° angle, must extend to back of excavation.
Thickness of the brushlayers depends on diameter of deadmen
Shrub willows 1-3 years old used in brush layers.
Width of bottom brushlayer - 1.30m. Successive layers are set back 300mm. This prevents brushlayers from shading one another, and increases capacity of channel as flows increase
Fill consists of parent material.
Top 2 brushlayers fertilized with 7-7-7 fertilizer.
Upstream end of cribwall returned into bank.
Exposed soil above wall seeded with oats and annual rye, covered with Anti - Wash Geojute.

Figure 1 a. Cribwall construction, brushlayer detail, typical section.

The cribwall was built into the bank so that the face of the wall was at the same location as the face of the slope. This was done so that the capacity of the channel would not be reduced. A hi-hoe was used to excavate the cribwall site. The logs for the crib were cut from an NVCA jack pine plantation. The wall itself was built by hand, and measured 40 m long, 1 m high, and 2.2 m deep at the bottom. The wall was canted back so that top brush layers would not shade bottom ones.

Shrub willow cuttings were harvested from sites within the watershed and transported to the cribwall site. Care was taken to time the harvest so that only fresh material would be used. Species of willow used at this site were:

Willow	*Salix eriocephala*
Sandbar willow	*Salix exigua*
Autumn willow	*Salix serrisima*

The cribwall was built in alternating layers of timbers, soil, and cuttings. Once the crib was completed, unused soil was removed from the site. Exposed soil was seeded with annual rye and oats, then covered with anti-wash geojute to prevent surface erosion. Live stakes (live rootable cuttings

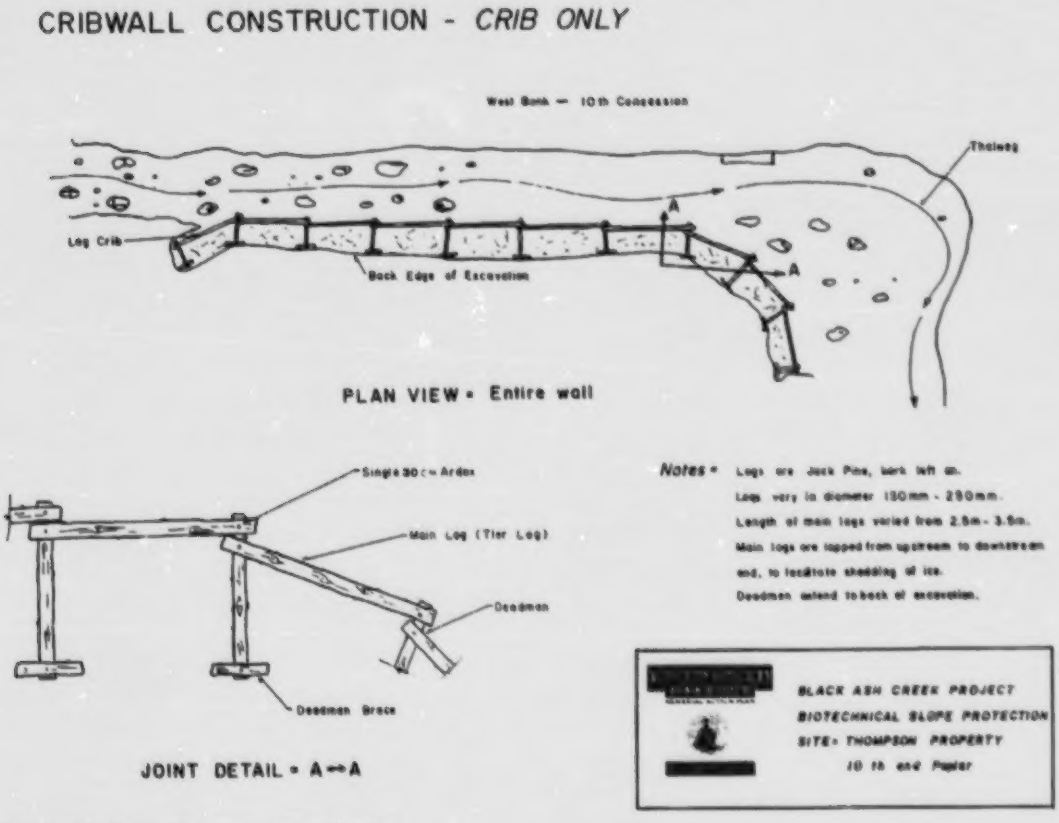

CRIBWALL CONSTRUCTION - CRIB ONLY
West Bank — 10th Concession
Thalweg
Log Crib
Back Edge of Excavation
A
A
PLAN VIEW • Entire wall
Single 30 cm Ardox
Main Log (Tier Log)
Deadman
Deadman Brace
JOINT DETAIL • A→A
Notes • Logs are Jack Pine, bark left on.
Logs vary in diameter 150mm - 250mm.
Length of main logs varied from 2.5m - 3.5m.
Main logs are lapped from upstream to downstream end, to facilitate shedding of ice.
Deadmen extend to back of excavation.
BLACK ASH CREEK PROJECT
BIOTECHNICAL SLOPE PROTECTION
SITE: THOMPSON PROPERTY
10 th and Poplar

Figure 1 b. Cribwall construction, crib only.

tamped into the ground) were placed at random in the jute.

The streambed was built up and protected from down cutting by placing 28 tonnes of rip-rap stone. Rip-rap stone was used instead of riverwashed or field stone because it is not as attractive, and therefore less prone to removal by motorists.

Because of the absence of any horizontal sinuosity, stream energy had to be dissipated by vertical sinuosity. This was achieved by placing the stone in a series of steps, attempting to establish a step-pool formation that is common to high gradient streams.

Photographs 1-5 show the site from pre-construction to finish.

Site 2

The first step at this site was to remove the instream debris (logjam), and any fallen or leaning trees. This material was either removed from the floodplain or stored nearby for later use. A low retaining wall was then constructed at the toe of the eroding bank, no higher than the bankfull mark. Open spaces behind this wall were filled with brush and debris taken from the debris removal. This material was used because the site was not accessible by machinery, and all works and to be completed by hand. The surface of the fill was left rough in order to catch sediments moving downstream during floods. This capturing of sediments would fill in all of the open spaces, and allow vegetation to succeed into the structure (Photograph 6).

The retaining wall was designed to undercut, so that it would create instream cover.

The eroding bank behind the wall was graded (slightly as it was done by hand) then seeded with a commercial grass seed. Once the seed was placed the entire bank was then covered with a monofilament based erosion control blanket.

Several current deflectors were built downstream of the retaining wall. These deflectors were constructed with a low profile, and were designed to work in a similar manner as the retaining wall. Coarse sands and silt were trapped by the defector, the vegetated by grasses and sedges, becoming part of the streambank.

During the spring of this year fascines were added to the slope to repair a section that had slumped during the previous fall. A fascine was also added to the crest of the retaining wall to provide more support, and to add a more vigourous vegetation type. The fascines were made using the same species of shrub willow as the cribwall. Typically the construction of bioengineered structures requires the use of dormant materials. dormant material is used because plant species that root from cuttings typically root better when dormant. The period of dormancy for shrub willows in this part of Ontario is typically late October to early April. Unfortunately for this project that also coincided with fall and spring high water levels. To avoid this, material was harvested during the early spring, placed into cold storage (to remain dormant) then used in the field once

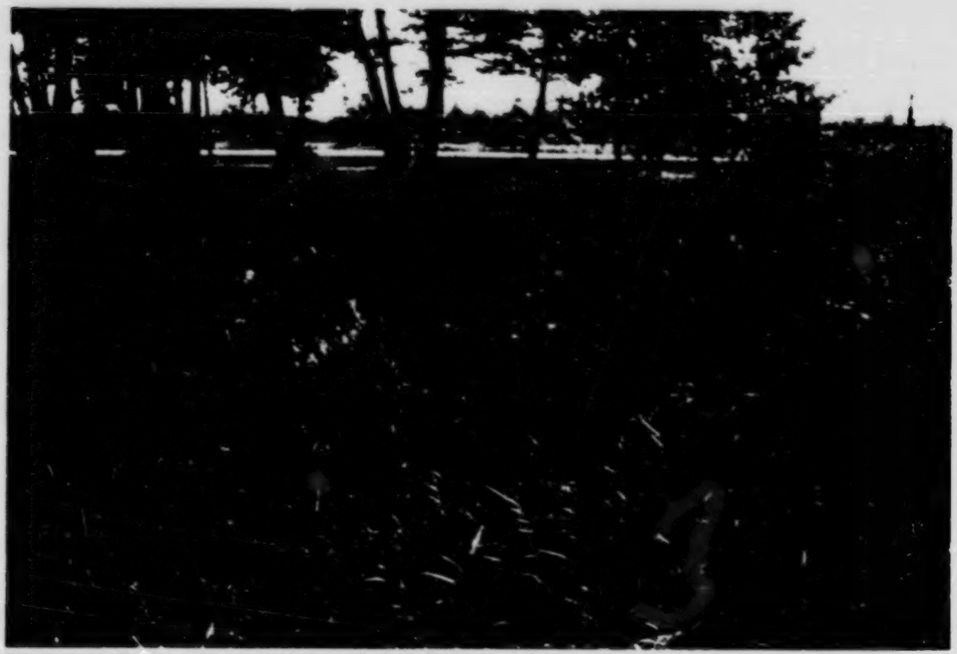
Site1

Photograph 1. The cribwall site prior to any stabilizaion efforts.

Photograph 2. The cribwall during construction.

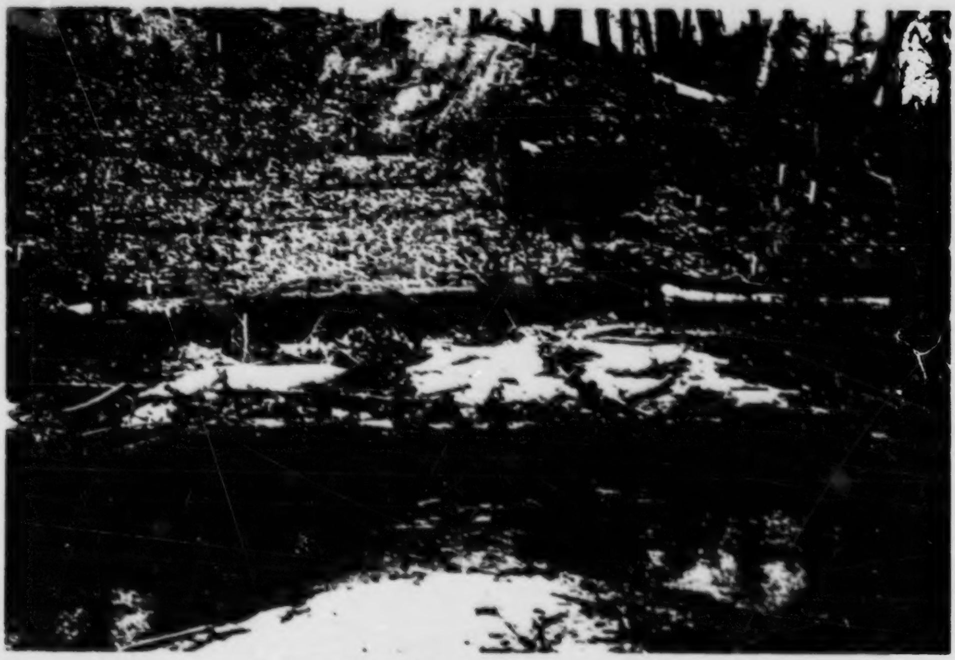
Photograph 3. The finished cribwall during the spring runoff. In channel volumes were such that during the peak, the ENTIRE cribwall was submerged. Velocities were high enough to place 35 cm rip-rap onto the wall.

Photograph 4. The cribwall 7 weeks after the cuttings have started to grow.

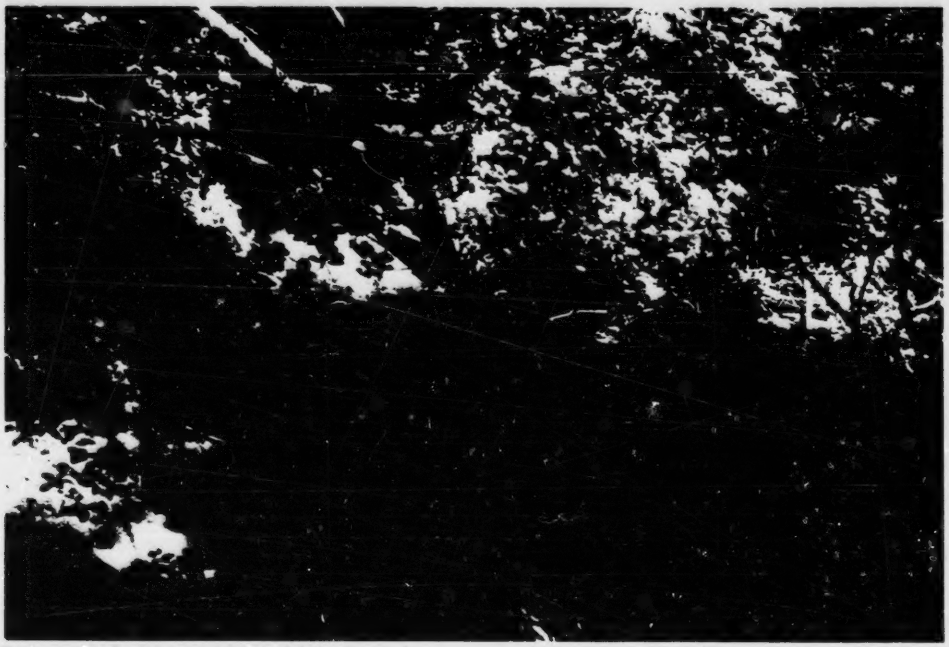


Photograph 5. The cribwall near the end of it's first growing season.

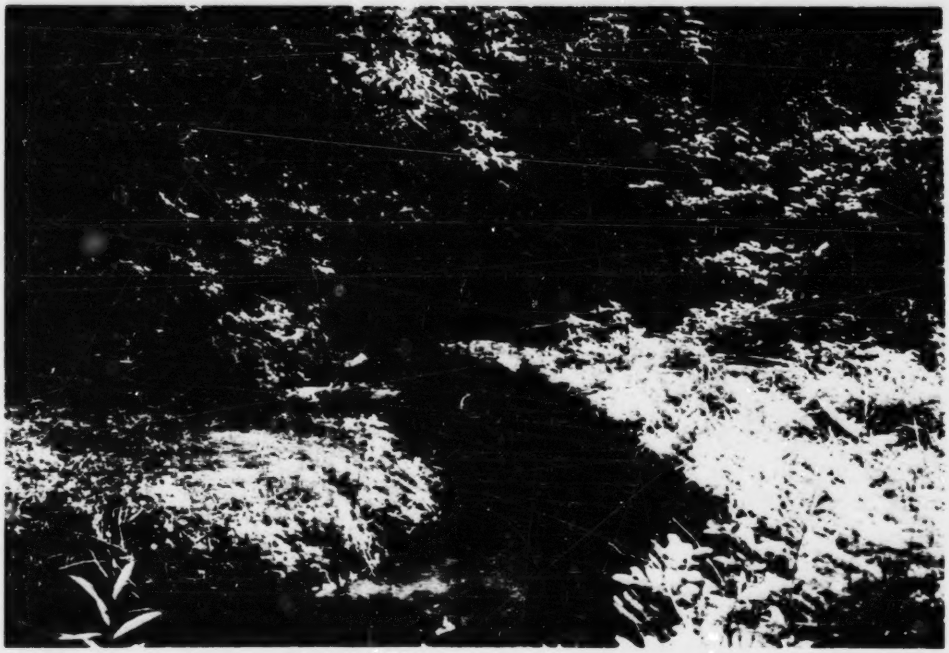
Site 2



Photograph 6. The sand and coarse silt deposited on top of the structure after its first flood.



Photograph 7. The site prior to debris removal.



Photograph 8. The same site (as Photograph 7) during the following summer.

conditions were satisfactory.

Photograph 7 shows the site prior to debris removal, and photograph 8 shows the same site during the following summer.

11. Degree of Environmental Intervention

Site 1

The stream at this site is intermittent. The fish community (cyprinids, catostomids) is non-existent during the summer, fall, and winter. Fish are present, likely as migrants, during the spring. The cribwall was built during the fall, while the channel was dry. Sedimentation was minimal, and the addition of bed materials would have affected no fish or macroinvertebrates.

Terrestrial habitats were disturbed during excavation of the site. Several fallen trees were removed by the contractor. A Woodchuck used the face of the cribwall as the entrance to it's burrow, and could be seen feeding on the developing willow shoots. The wall was not damaged by this browsing.

The materials used in the cribwall were native, and harvested from within the same sub-watershed as the cribwall site. The disturbed soils above the wall were seeded with annual rye and oats. These species were selected as they provide immediate cover, but as annuals will allow native (or naturalized) plants to take over the site.

Site 2

Initial debris removal occurred during the summer months, well after the emergence of rainbow trout (this was an MNR requirement). Instream habitat was altered by the debris removal, but this alteration was mitigated by the re-appearance of spawning substrates, and the creation of an undercut bank. Sedimentation of downstream habitats was minimal, partly because of the installation of downstream deflectors, and the low height of the retaining wall, captured much of the coarse material that was released.

As in the cribwall site, all material used was either native or naturalized to the area.

12. Cost

Site 1

Thompson Property Cost/Time Requirements

Effort

Effort is given in person hours or p/h. It is broken down into the various commitments required by the project. Measuring and Design includes time spent with consultants, township superintendents, landowner contact, and securing of contractors and materials. Site preparation involved working with the contractor in removing trees, grading the site, and the placement of the riprap in the streambed. Placement of the material is the construction of the wall.

Requirements	Person/Hours
Measuring and Design	48
Site Preparation	27
Cutting/Transporting Material	48
Placement of Material	108 (40)*
Repairs to Lawn	12 (60)*
Total	243 + (100)* = 343

* Time spent by the Salvation Army Intermittent Program. This is classed as voluntary.

Costs: Wages

Wages are broken down as to Field Supervisor (FS) and Crew (C).

Requirements	Wages		
	Field Supervisor	Crew	Total
Measuring and Design	$772.00		$772.00
Site Preparation	$161.00	$150.00	$311.00
Cutting/Transporting Materials	$193.20	$360.00	$553.20
Placement of Materials	$434.70	$810.00	$1 244.70
Repairs to Lawn	$48.30	$90.00	$138.30
Totals	$1 609.20	$1 410.00	$3 019.20

Materials

NOTE: Costs do not include: tools, truck rental, fuel, office costs, indirect support for the crew, or permit fees. It would be impossible to separate these cost as they were used, or required on more than one site. Costs listed here where specific to this site only.

Materials	Description	Cost
Consultants	Harrington and Hoyle Ltd. – consultation on design and construction.	$800.00
Logs for Cribwall	Free !! from NVCA, Cost is for transport to site.	$50.00
Contractors	Paul Forbes Construction. – highhoe, backhoe work, haulage of leftover fill.	$1 423.10
Plant Cuttings	Free !! Cost is for the rental of the clearing saw used in harvesting.	$300.00
Rock	Seely and Arnill - 22 mt of riprap stone.	$297.28
Geojute	Soil Enrichment Systems. – 1 roll Antiwash Geojute.	$122.13
Spikes	50 lb of 12 inch ardox.	$30.00
Tim Hortons	Delivery of coffee and donuts to volunteers.	$56.25
Fertilizer/Seed	Fertilizer and grass seed to repair the lawn and complete site.	$40.00
Topsoil	For repairs to lawn.	$250.00
Rental of Lawn Rollers	For repairs to lawn.	$10.00
Totals		$3 378.76

Summary

Total Person Hours	343
Total Wages	$3 019.20
Total Materials	$3 378.76
Total Cost	**$6 397.96**

Site 2

Costs were not available at the time of writing.

13. Biological Assessment

Site 1

There were no pre-construction or post-construction biological assessments of this site.

Site 2

Biomass surveys were conducted at two sites on Black Ash Creek. A 75 m long treatment station was run immediately downstream of the rehabilitation site (Figures 2-3). The 1992 data (prior to rehab.) revealed a population of 1 young-of-the-year (YOY) rainbow trout (at 95% conf. interval 1 +/- 0.004). In 1993 the YOY rainbow trout estimate for that same station was 23 (interval 20-

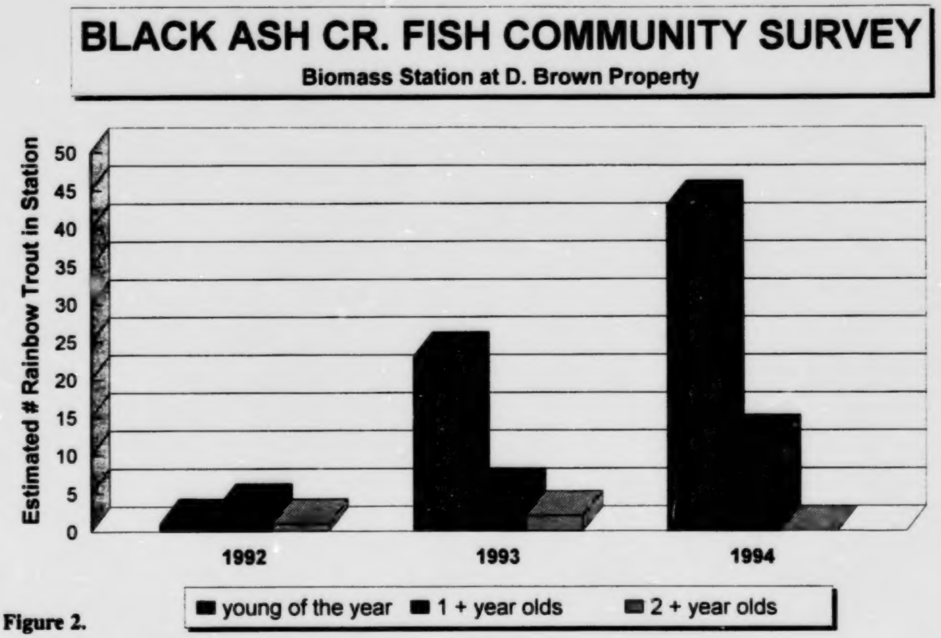


Figure 2.

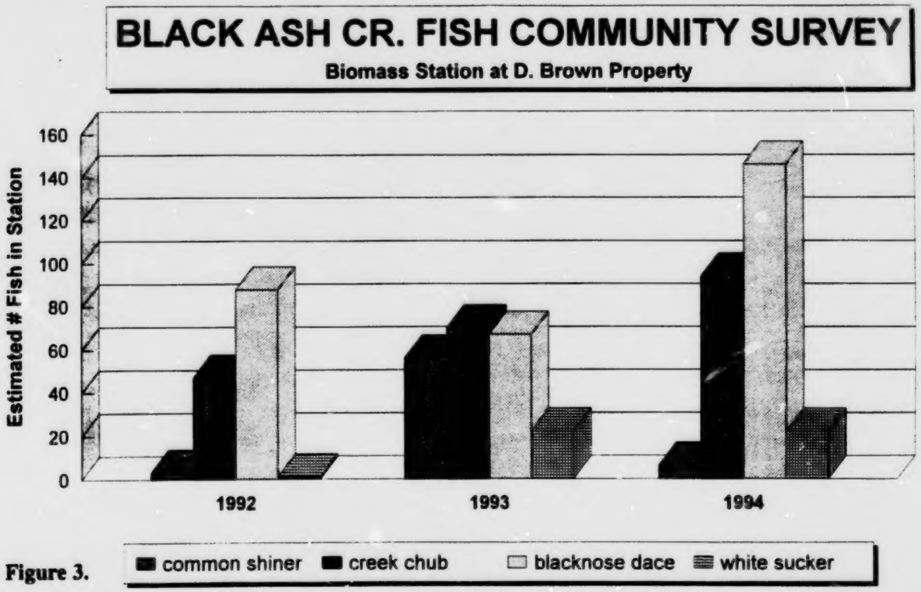


Figure 3.

27) and in 1994 was 43 (interval 40-46). This is being called a statistically significant increase in YOY rainbow trout production. If confidence intervals for the population estimates did not overlap, they were considered statistically different. Fish community information is displayed in the attached graphs. Other fish species also increased in number or remained constant. The only exception to this is common shiners, which decreased in 1994.

At the control station ot Osler Bluff Road (Figures 4-5) fish populations either decreased or remained constant. The 1994 exceptions to this are for fathead minnow and mottled sculpin. The YOY rainbow trout numbers are misleading in a graph form because the confidence intervals overlapped for all 3 sampled years. In 1992 the estimate was 227 (interval 135-319), 1993 was 181 (interval 165-198), and in 1994 was 133 (interval 130-136). Statistically it would be difficult to prove a change in numbers.

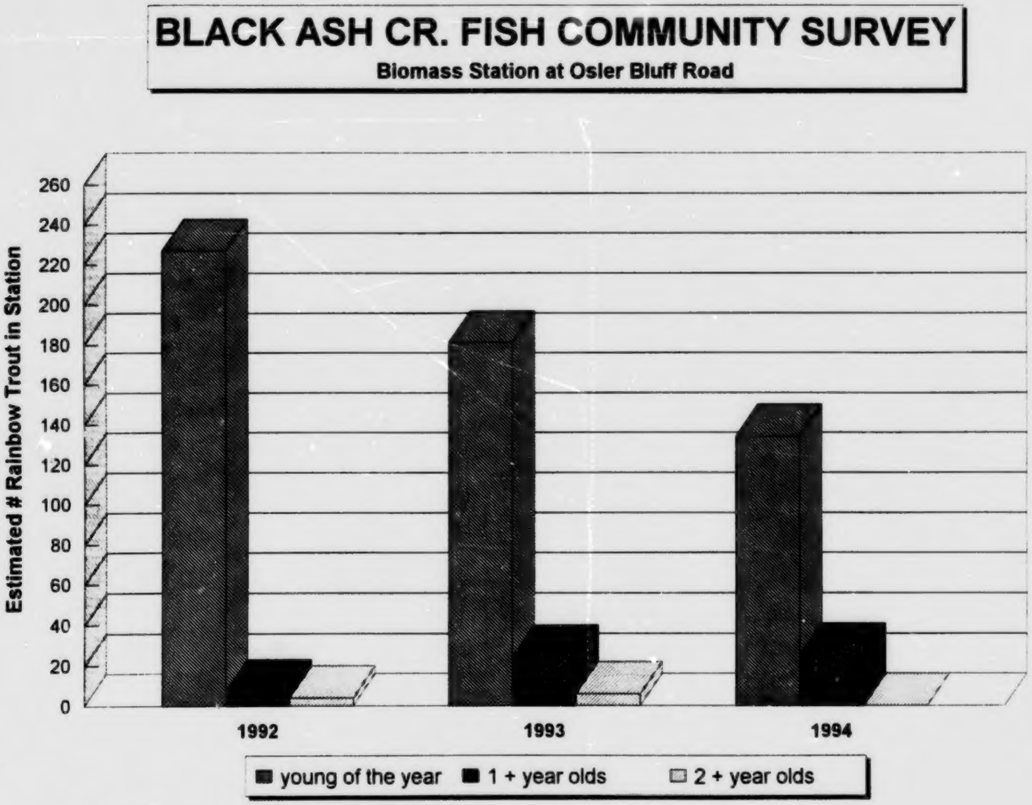


Figure 4.

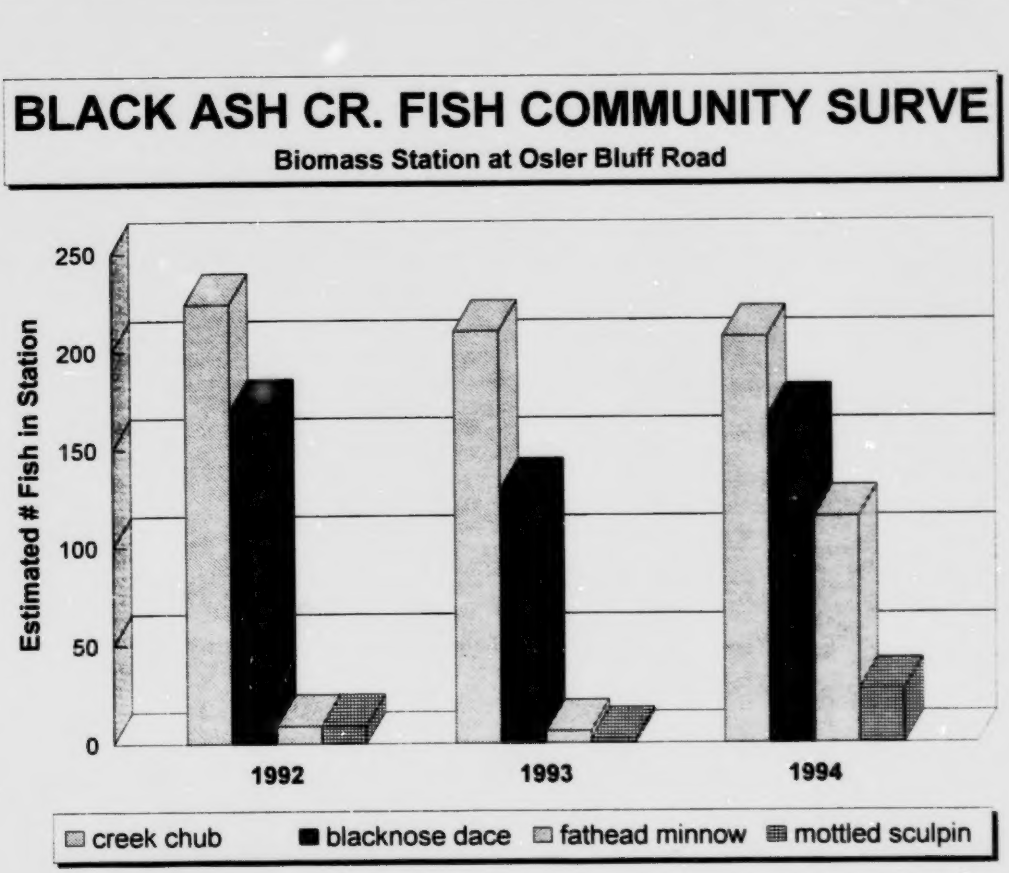


Figure 5.

14. Measures of Success

Site 1

The streambank at this location is completely vegetated. Erosion has been reduced to insignificant. The cribwall successfully weathered the spring flows, which often saw the structure completely submerged. Growth from the cuttings has been vigourous, with *Salix eriocephala* becoming the dominant willow.

Success Rating: 5

Site 2

This site has also been stabilized. The fascines are growing well, and the slope is vegetated. The stream habitat is stable, with the retaining wall providing a deep, stable undercut pool. Population estimates of rainbow trout YOY are on the increase, and are expected to continue to increase.

Success Rating: 5

15. Key References

Collingwood Harbour Remedial Action Plan Stage 2 Report: A Strategy for restoring the Collingwood Harbour Ecosystem and Delisting Collingwood Harbour as an Area of Concern.1992. Prepared by the Collingwood harbour RAP team, in consultation with the Public Advisory Committee.

Dobbs, F., and Grillmayer, R. 1994. Black Ash Creek Rehabilitation Project Implementation Report. ISBN 0-7778-2696-8. 86p.

Sotir, R., and Gray, D.H. 1989. Fill Slope Repair Using Soil Bioengineering Systems. *In* Public Works, December 1989.

Correct citation for this contribution:

Grillmayer, R. 1995. Soil bioengineering for streambank protection and fish habitat enhancement, p. 82–98. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 14

1. **Projet Title: Restoring Breeding Ospreys in the Upper St. Lawrence River – A Case Study**

2. **Contacts**

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Conservation Strategies Division, Environmental Conservation Branch,
Environment Canada – Ontario Region,
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John Mackenzie
Ontario Ministry of Natural Resources,
P.O. Box 605, Oxford Avenue, Brockville, Ontario, K6V 5Y8.
Tel.: (613) 342-8524; FAX:(613) 342-7544

Bud Andress
St. Lawrence Islands National Park, #2 County Road 5,
Mallorytown Landing, Ontario,KOE 1RO.
Tel.: (613) 923-5261; FAX:(613) 923-2229

3. **Agencies Involved**

Canadian Wildlife Service, Environment Canada
Canadian Parks Service
Ontario Ministry of Natural Resources
Ontario Hydro
Kingston Field Naturalists
Cardinal Fish and Game Club
Muttart Building Supplies

4. **Restoration Goals**

To provide suitable nest structures for Ospreys in areas where natural nest sites are scarce. To increase public awareness of the shortage of natural nest sites, and the need for conservation action.

5. **Project Type**

Construction and installation of wooden nesting platforms mounted on old hydro poles at small rocky islands adjacent to suitable fishing areas.

6. Background and Rationale

Ospreys (*Pandion haliaetus*) are majestic, large birds of prey (raptors), which eat fish up to about 30 cm long. They catch fish mostly in shallow water (up to 2 m deep) by diving with wings closed from heights of up to 20 m or so. Most Ospreys which breed in Canada and the United States winter in South or Central America. They build large stick nests in exposed sites, preferably over or close to water. In this way, they reduce the risks of egg predation from raccoons, and they get sufficient aerial manoeuvrability when approaching or leaving the nest (Poole 1989). In the Great Lakes, the clutch of 3 eggs is laid in late April, and the chicks usually fledge by early August.

Before European settlement of the Great Lakes, Ospreys probably bred commonly around most shorelines close to productive river systems and other shallow water areas. Their nests would have been built at the very top of large trees, live or dead, which had sufficient side branches to provide firm support for the heavy nest. Today, the shorelines of the upper St. Lawrence River, like many around the Great lakes, have been developed for human habitation and recreational activities. As a result, there are now very few suitable natural nest sites there for Ospreys. A few pairs have attempted to nest in snags in beaver swamps, or in live white pines further from the river, but the nests often fall down on these smaller trees, and raccoons can readily climb trees on dry land, and will swim out to snags too (Ewins 1994).

Osprey populations in the Great Lakes, as in many other breeding areas, have been increasing steadily since the 1970s, when DDT and other toxic organochlorine pesticides were withdrawn from use (Poole 1989; Ewins *et al.* 1995). Although it is well known that DDT causes eggshell thinning in many bird species, it is still widely used in Latin America. Our preliminary surveys indicated that the upper St. Lawrence River offered suitable fishing areas for Ospreys, but probably a shortage of safe, suitable nest sites close to the fiver. In other parts of the Great Lakes and North America, Ospreys regularly build their nests on hydro poles and other types of artificial nest-structure (Ewins 1995; Ewins *et al.* 1995). So, a cooperative project was launched in the fall of 1992 to install 5 artificial nesting platforms on suitable small, rocky islands in the Upper St. Lawrence River.

7. Regulatory Considerations

a) Ontario Ministry of Natural Resources permit required for egg collecting/chick sampling.
b) Canadian Wildlife Service permit required for banding birds.
c) Landowner permission is required for platform installation.

8. Criteria

The extent of suitable shallow water foraging areas (less than 2 m deep) was assessed from hydrographic charts, and speaking to locals who had seen Ospreys fishing in various stretches of the river.

An aerial survey of the general area, including the archipelago of islands within the river itself, was conducted between Kingston and Mallorytown. This survey identified at least 40 potentially suitable sites for a platform. Most of these potential nesting sites were small (less than 1-2 ha) rocky islands lacking tree cover. All were uninhabited. All platforms were later placed at exposed, treeless parts of each island, at least 300 m away from the nearest cottage. A few pairs of Ospreys were known to breed within 20 km of these areas. Experience elsewhere has found that the chances of platform occupation within a few years are much higher when birds are already nesting in the general area.

Local resource agency staff (OMNR, Canadian Parks Service) identified landowners for sites targeted, and sought support for the project. At least 6 landowners were keen on the idea of having an Osprey nesting platform on their property.

Once all this had been done, 5 sites were selected between Mallorytown and Rockport. Sites were at least 2 km apart, so reducing the chance of intra-specific / territorial interference from adjacent pairs.

Inventories of breeding colonial fish-eating birds were checked to ensure that no Osprey platform was installed on an island used by breeding Common Terns or other sensitive fish-eating birds, which might be forced to vacate the site if breeding Ospreys moved in.

9. Project Design

Details of the various design and construction options for artificial nest platforms for Ospreys are provided in a published manual on Osprey platforms (Ewins 1994). The basic design used in the St. Lawrence River was a rock-mounted shortened hydro pole with a modified industrial pallet mounted on top. Coordination of a number of partners on the ground ensured that the installation process went smoothly.

Although this kind of platform has been successfully installed in other areas in mid-winter, unpredictable ice conditions in the St. Lawrence River made access over ice dangerous, so the work was done using boats before freeze-up in the fall of 1992.

10. Implementation

An old hydro pole, usually cut to 8–10 m, with a 1m × m skid/industrial pallet mounted on top of the pole, using side walls and support braces was used. The cast iron rock mounts were first bolted deep into the bedrock, then the whole structure was raised upright using a block and tackle. Three galvanised guy wires provide valuable additional support in other areas, but were not used in this case. Anti-predator guards (sheet metal nailed carefully around the base of the pole) were not installed on these poles, but will be added before the 1995 breeding season. The basic pole and platform design was as shown in Figure 1, minus the guy wires and predator guard. Also, the

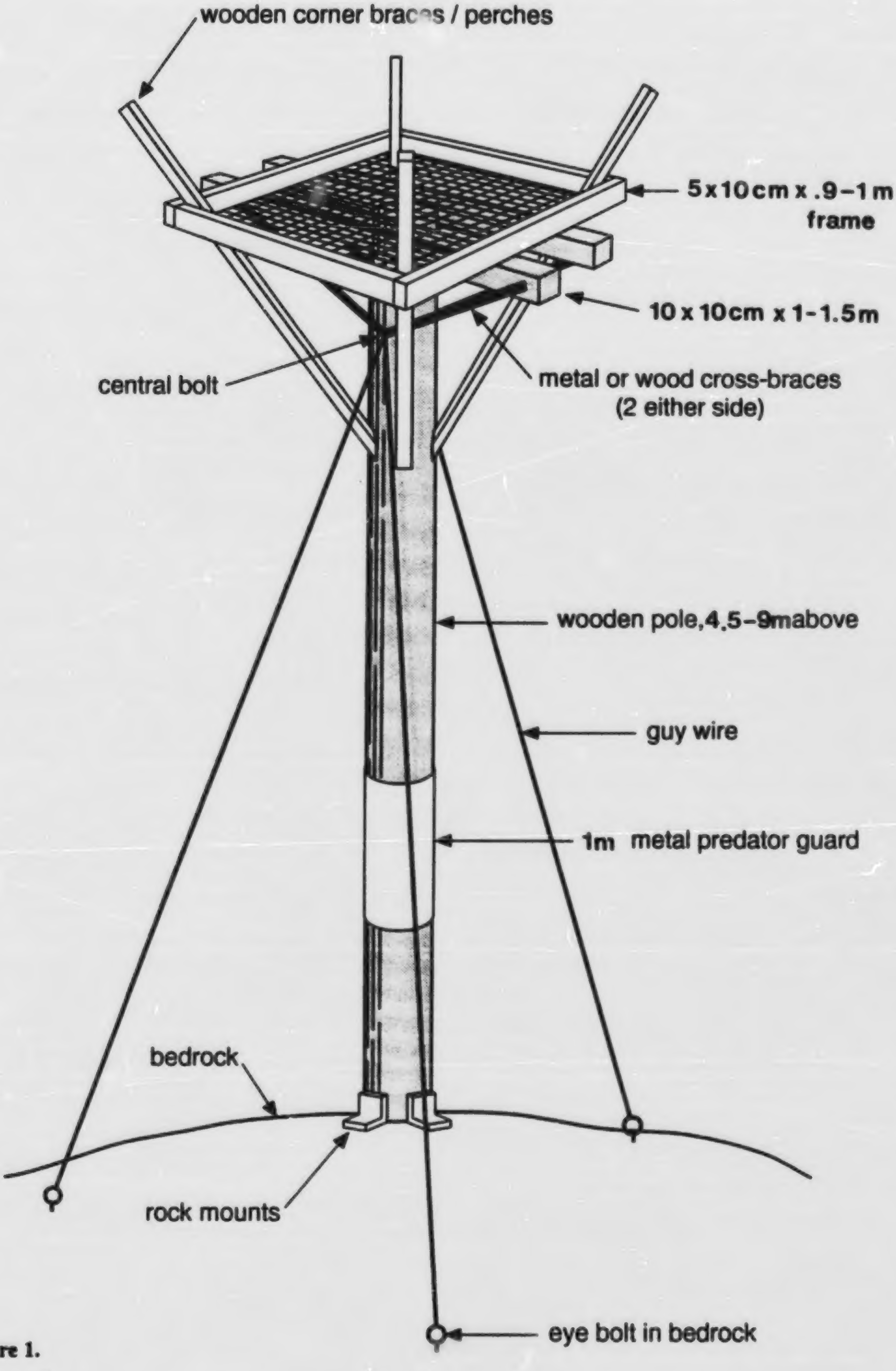
wooden corner braces / perches
5x10cm x .9-1m frame
10x10cm x 1-1.5m
central bolt
metal or wood cross-braces (2 either side)
wooden pole,4.5-9mabove
guy wire
1m metal predator guard
bedrock
rock mounts
eye bolt in bedrock

Figure 1.

platform base was wooden slats on the pallet, not a wire grid. Either design will do though.
In the fall of 1993, 5 platforms of this type were installed on small islands in Canadian waters of the St. Lawrence River between Mallorytown and Rockport.

11. Degree of Environmental Intervention

This work had minimal impact on the physical structure of islands used. Although poles and wood treated with chemical preservatives will last longer, in some smaller, more sensitive water bodies it may be preferable to use cedar and untreated poles. Although no study was carried out to investigate changes in other biota using these islands, it is likely that some limited changes would occur. These include some enrichment of the ground beneath the nest, from faeces and pieces of dropped fish, and desertion of the island by any breeding animals which could not tolerate such close proximity to a nesting raptor. However, many species are thought to gain increased protection from ground predators when nesting close to a large bird like this.

12. Cost

Some staff/volunteer costs were donated by individuals and partner organisations involved with the project. These items are listed below as "Free ". The poles and rock mounts would have been by far the most expensive items if they were bought new. However, used ones can often be found from local offices of public utilities, once they are approached as potential partners. Approximate costs (for 5 platforms) were as follows:

Installation

Poles, support braces, and rock mounts:	Free
Pallets and support timbers:	Free
Assorted timber, nails and hardware:	$30
Chicken wire for platform base:	$30
Rental of jack hammer:	$300
Bits for jack hammer: $150	
Purchase of insulated waders:	$100
Incidental safety equipment:	$100
Transportation for work crews (boats):	Free
Boat fuel: $150	
Boom barge and tow boat use (incl. fuel):	Free
Video film and photo equipment:	$250
Total cost (for 5 platforms)	**ca. $1 110**

Annual monitoring and maintenance:

Usually these sites can be checked for occupation during the course of other work, so no specific additional costs for staff time are incurred. Average annual maintenance costs after the platforms are about 5 years old are estimated to be about $10 per platform (to cover replacement side walls, and possibly guy wires if poles start to lean). It is expected that soundly built platforms would need maintenance only every 5-10 years or so.

13. Biological Assessment

Since 1993 all sites have been checked at least twice annually. A visit in mid-May determines whether the site is occupied (usually by seeing a bird incubating or standing at the side of the nest). A second visit in early to mid-July counts the number of large young produced, to allow calculation of mean reproductive success for the area. At these St. Lawrence River nests prey remains and a small blood sample from chicks were also collected (for analysis of organochlorine contaminant levels). All chicks have been banded, to enable biologists to assess whether birds are surviving to recruit back into the local breeding population (Ospreys usually first breed when 3-5 years old). Annual checks of this kind are recommended to monitor the health of the local Osprey population. From the prey remains (fish bones), we have confirmed for this breeding area that shallow, warm-water species of fish form the bulk of the diet - mostly suckers, bullheads, yellow perch, pike and centrarchids (sunfish, pumpkinseed, rock bass etc.).

14. Measures of Success

In 1993, the first season after installation, 3 of the 5 platforms were occupied, and all were successful, producing an impressive total of 8 large young by mid-July (average production of 2.7 young per occupied nest).

In 1994, all 5 platforms were occupied, and 4 produced large chicks by mid-July (at 4 of the accessible platforms, 6 large young were produced, i.e. 1.5 young per occupied nest on average). One nest failed in 1994 - the remains of broken eggs in the nest and fresh claw marks up the pole implied raccoon predation. This rapid rate of occupation exceeded eveyones expectations. In other areas it may take 4-5 years or more for platforms to become occupied, especially where Ospreys are not nesting already in the immediate vicinity.
Generally, if an Osprey population is producing a mean of 0.8 young per occupied nest per annum, then it is thought likely to be able to maintain itself.

The local press attended some of the platform installations, and the articles which resulted were well received, and a fitting recognition of the efforts of all partners. The occupation of all 5 platforms within 2 years was a wonderful achievement, and many cottagers and boaters along this stretch of the St. Lawrence River now enjoy the thrilling spectacle of fishing and nesting Ospreys from April through August each year.

Success Rating: 4

15. Key References

Ewins, P.J. 1995. Artificial nesting platforms for Ospreys: a construction manual. Environment Canada: Toronto (in press).

Ewins, P.J. 1995. The use of artificial nest sites by an increasing population of Ospreys in the Canadian Great Lakes basin. J. Raptor Res. (in press).

Ewins, P.J., Postupalsky, S., Weise, T. and Addison, E.M. 1995. Changes in the status, distribution and biology of Ospreys (*Pandion haliaetus*) breeding on Lake Huron. J. Aquat.Ecosystem Health (in press).

Poole, A.F. 1989. Ospreys. Cambridge University Press, Cambridge, U.K.

Correct citation for this contribution:

Ewins, P.J., Mackenzie, J., and Andress, B. 1995. Restoring breeding ospreys in the upper St. Lawrence river – A case study, p. 99–105. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 15

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1. Project Title: McKellar River Habitat Creation Project

2. Contact

Karen Bray
North Shore of Lake Superior Remedial Action Plans
1194 Dawson Road, R.R. #12, Site 8-16, Thunder Bay, Ontario P7B 5E3
Tel.: (807) 768-2112; FAX: (807) 768-1889

3. Agencies Involved

North Shore of Lake Superior Remedial Action Plans*
1194 Dawson Road, R.R. #12, Site 8-16, Thunder Bay, Ontario P7B 5E3
(* Includes Environment Canada, Great Lakes Cleanup Fund, Ontario Ministries of Natural Resources and Environment and Energy)

Great Lakes Laboratory for Fisheries and Aquatic Sciences
Department of Fisheries and Oceans, GLLFAS
1 Canal Drive, Sault Ste. Marie, Ontario P6A 6W4

4. Restoration Goal

Enhance habitat diversity and aquatic productivity in a dredged navigation channel and demonstrate techniques for enhancing the littoral zone and creating wetland habitat.

5. Project Type

Excavation of shallow embayments open to the river to increase littoral zone and provide critical habitat for resident and migratory fish species, herptiles, and birds.

6. Background and Rationale

The McKellar River is the middle of three short channels comprising the Kaministiquia river delta flowing into Thunder Bay harbour (Figure 1). Decades of use as a commercial shipping route has produced a straight, deep channel and a shoreline partly armoured with steel sheet piling and concrete. Elimination of most of the shallow littoral zone has left the river with little in the way of habitat productivity or diversity. Poor water quality and contaminated sediment from industrial activities upstream have compounded the problem for aquatic organisms.

Use of the McKellar River for commercial shipping has ceased and there appear to be no plans to recommence dredging or to reopen the river to commercial traffic. The channel is now used mostly for recreational craft. There is a private marina and a public boat launch on the south side of the river and a public marina has been proposed by the City of Thunder Bay. Water quality has improved somewhat as a result of better pollution control by industries upstream and further improvements are planned.

The goal of the McKellar River Project is threefold:
a) to restore and enhance estuarine habitat diversity in the McKellar River;
b) to demonstrate techniques for rehabilitating a dredged navigation channel; and
c) to provide increased recreational opportunities and waterfront access.

7. Regulatory Considerations

a) Completion of an Ontario Ministry of Natural Resources Class Environmental Assessment for Water Related Excavation, Dredging, and Fill Activities.
b) Acquisition of an exemption from the Navigable Waters Protection Act.
c) File a Government of Canada Environmental Assessment Review Process Screening

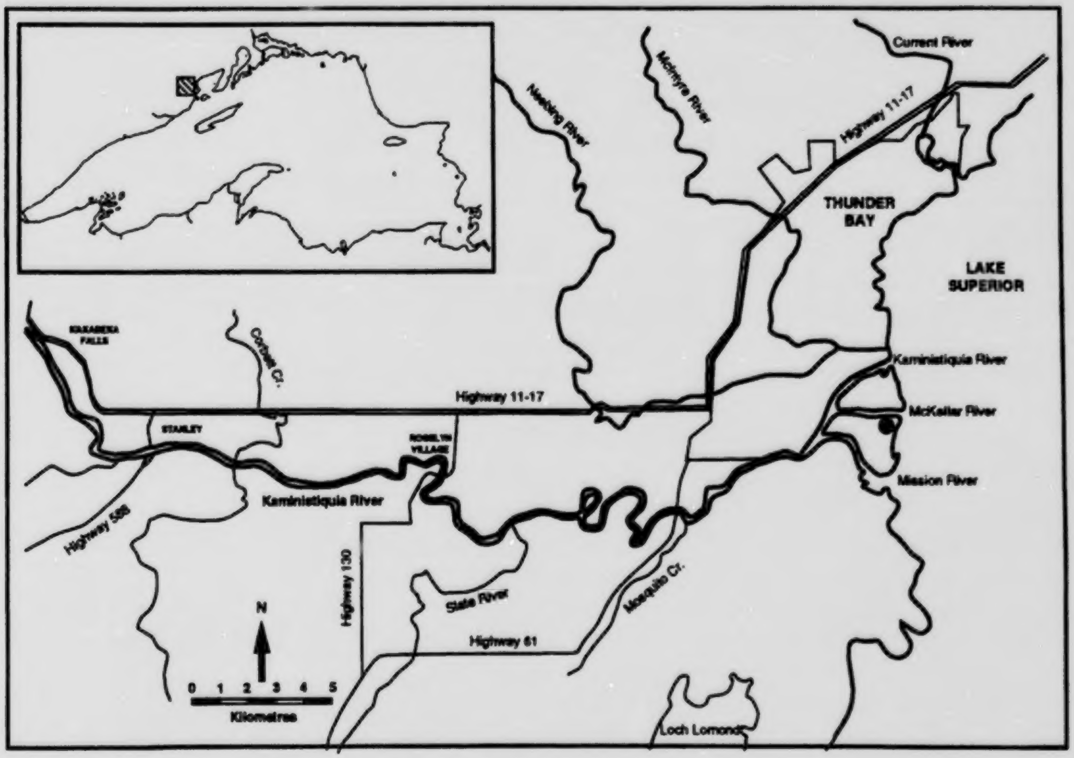

Current River
McIntyre River
Neebing River
Highway 11-17
THUNDER BAY
LAKE SUPERIOR
KAKABEKA FALLS
Corbett Cr.
Highway 11-17
STANLEY
ROSSLYN VILLAGE
Kaministiquia River
McKellar River
Mission River
Kaministiquia River
Highway 588
Highway 130
Slate River
Mosquito Cr.
Highway 61
N
0 1 2 3 4 5
Kilometres
Loch Lomond

Figure 1. McKellar River and Thunder Bay Harbour – Area of Concern

Decision Document.

d) Ensure the substrate of the embayments conforms with the Ontario Ministry of Environment and Energy Lake Filling Guidelines.

8. Criteria

The physical dimensions of the embayments are determined by constraints of the site and concerns raised during the environmental assessment. The size is determined by the boundaries of property lines, an access road to the south, and the presence of an underground coal conveyor system located between the two ponds.

9. Project Design

Basin morphometry was designed to minimise deep excavation adjacent to the coal conveyor while still encouraging circulation and providing diversity of habitat. Three wetland pockets <1m deep are designed to help improve water quality in the main basins by settling out suspended solids from overland runoff. These small pockets are connected to the basins with 2-stage culverts which allow for daily flushing and settling as water levels fluctuate. Additional habitat features, such as a mud flat, shallow depressions in the adjacent woodlot for amphibians and a sand bluff

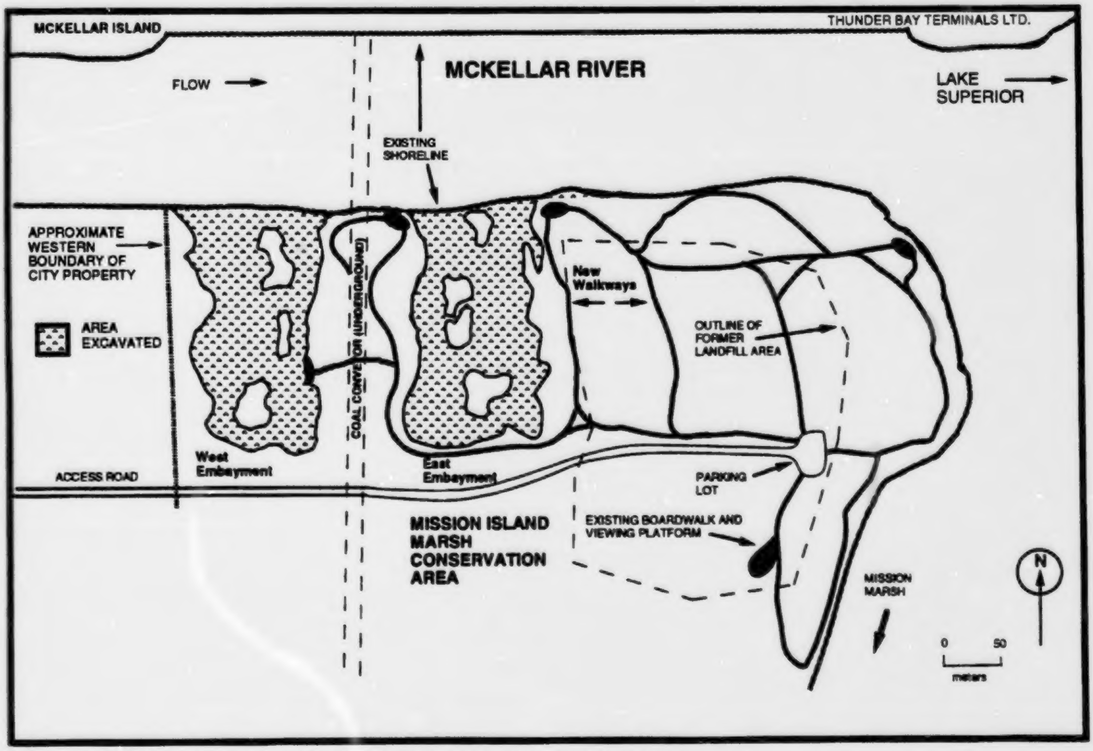

MCKELLAR ISLAND
THUNDER BAY TERMINALS LTD.
MCKELLAR RIVER
FLOW
LAKE SUPERIOR
EXISTING SHORELINE
APPROXIMATE WESTERN BOUNDARY OF CITY PROPERTY
▨ AREA EXCAVATED
COAL CONVEYOR (UNDERGROUND)
New Walkways
OUTLINE OF FORMER LANDFILL AREA
West Embayment
East Embayment
ACCESS ROAD
PARKING LOT
MISSION ISLAND MARSH CONSERVATION AREA
EXISTING BOARDWALK AND VIEWING PLATFORM
MISSION MARSH
N
0
50
meters

Figure 2. Habitat enhancement plan for McKellar River/Mission Island site.

for bank swallows are being considered (Figure 2).

10. Implementation

Excavation of the embayments began in March, 1994, and both ponds were open to the river by April 2, 1994. The basins were dug in dry conditions with a plug to prevent inundation left at the river's edge and the basins allowed to slowly fill with water before the dirt plug was removed. A portion of the fill was placed on a long closed landfill site in the adjacent Mission Marsh Conservation Area. Habitat features in the basins included gravel shoals, sand spits, boulder edges, tree crowns, and root fans, the latter two added as they became available.

In the summer of 1994, topsoil was spread over the stockpile site and that, plus all areas disturbed during construction, hydroseeded to stabilize the area until planting of larger vegetation can occur in 1995. Site works, such as walkway construction and resurfacing, grading and seeding, continued throughout the summer when conditions were more favourable.

11. Degree of Environmental Intervention

Approximately 15 ha of land on Mission Island were disturbed as a result of this project. This includes the two embayments, the Mission Marsh Conservation Area, and an adjoining private property where excess fill was stockpiled. Most of the area disturbed was either open, grassy field or low, wet shrubland which characterises much of the remainder of the island. Unless absolutely unavoidable, as in a portion of the land used for the embayments, woodlots on public land were left intact. Despite all efforts to restrict construction activities to minimise disturbance to organisms and habitats, there is no doubt that some destruction of habitat and displacement of animals has occurred. The net gain in habitat productivity, however, is deemed to outweigh any losses.

12. Cost

Pre-construction:	
Detailed design	$17 410
Environmental assessment – coal conveyor	15 025
Environmental assessment – substrate	10 675
Environmental assessment - soil leachate	5 350
Environmental assessment - land survey	980
Environmental assessment - newspaper ads	1 190
Subtotal, Pre-construction	$50 630
Construction:	
Construction contract	$544 000
Engineering supervision	21 000
Aquatic plants	24 840

Terrestrial plants	17 960
Subtotal, Construction	$607 800
Assessment (estimated):	
Field crew 5.3 person weeks/year, 5 yrs.	$20 160
Benthos sample sorting 830 samples @ 9.00	7 470
Benthos taxonomy 830 samples @40.00	33 200
Sr.Scientist/Biologist 1 week/yr., 5 yrs.	5 000
Data analysis/report writing 3 @3000 (avg)	9 000
Subtotal, Assessment	$74 830
Total Estimated Project Cost	**$733 260**

13. Monitoring and Assessment

There are two main objectives of the monitoring program:

1) a long-term, continuing program to document changes in physical structure, chemical composition, and community dynamics not only for the sake of observing change, but to evaluate the embayments for their contribution to biological productivity and demonstrable technologies; and
2) a short-term evaluation of water quality and circulation to fulfil federal EARP requirements for approval to construct Phase II.

In the first year, benthos and water quality were sampled once a month from May to October. Benthos samples were taken using a petite ponar at 6 sites in each embayment with four replicates each; an additional 2 sites in each embayment were sampled using a sweep net. Water samples were collected at a depth of 1 m in each of the two back bays and one sample was taken at the mouth of the west embayment. Parameters measured included pH, conductivity, alkalinity, turbidity, TSS, nitrates, phosphates, and chloride. Temperature and dissolved oxygen profiles were taken in each embayment, one shallow (approx. 1 m) and one deep (2.5 m), and recorded continuously from May to October. The fish population was sampled using a variety of gear types including minnow traps, trap nets, fyke nets, and an electrofishing boat. Winter conditions, such as ice cover and movement, will be also be monitored.

14. Measures of Success

Success Rating:

4 – successful (initial stages)
1 – assessment incomplete (long term)

Monitoring physicochemical change and ecological succession will be important for evaluating the success of this project. Specific measures of success, such as plant densities, plant and animal biomass, water quality criteria, or presence of specific species, may not be as desirable as the more poorly defined and less quantifiable targets of diversity, trophic level representation, and habitat use. It may be more important to document conditions and use rather than assessing the success in terms of specific standards. Therefore, development of diverse and self-sustaining communities with representation from all trophic levels will be an indication of success.

Initial colonisation by a variety of organisms which indicate good water quality and the maintenance of adequate circulation in the embayments demonstrates success in the early stages. Ongoing monitoring of the fish, benthos, and plant communities, and changes to basin morphometry will indicate success in the longer term. The scale, however, for achieving a fully functioning "natural" system may be anywhere form ten to several hundred years, depending on the variable.

15. Key References

None.

Correct citation for this contribution:

Bray, K. 1995. McKellar River habitat creation project, p. 106–111. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 16

1. **Project Title: Severn Sound Tributary Rehabilitation and Erosion Control Program**

2. **Contact**

Robin Craig
Ministry of Natural Resources, Midhurst, Ontario, LOL 1XO
Tel.: (705) 725-7500; FAX: (705) 725-7584

3. **Agencies Involved**

Partnership List to Date
Ministry of Environment and Energy
Ministry of Natural Resources
Ministry of Agriculture and Food
Agriculture Canada
Environment Canada
Great Lakes Cleanup Fund
Jobs Ontario
Wye Marsh Wildlife Centre
Landowners of Severn Sound Watershed
Tiny Township
Midland Area Boy Scouts/Girl Guides
Barrie and Midland Big Brothers
Elmvale Junior Farmers
CFIP/CWIP
Orillia Fish and Game Club
Hog River Valley Conservation Club
Local Chapter of Steelheaders Club
Elmvale 4H Club
Midland Field Naturalists
Local Schools
Midland Rotary
Ducks Unlimited
Severn Sound Remedial Action Planning Team
Severn Sound Public Advisory Committee
North Simcoe Soil and Crop Improvement Association
Local Media

Past Partners
Trout Unlimited

Cleansweep
Environmental Partnership Fund

4. Restoration Goal

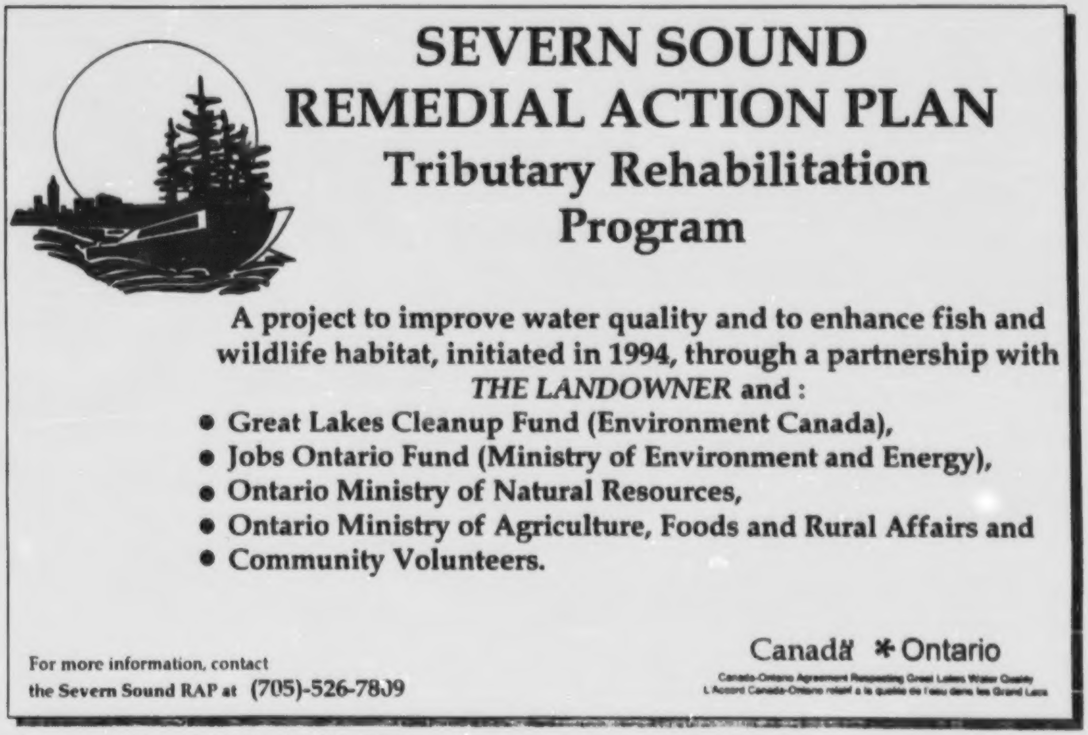
To improve water quality in the Severn Sound, decrease phosphorus input to reduce the growth of "nuisance" algae, streambank stabilization and habitat improvement in and along stream areas.

5. Project Type

Rehabilitation of streambanks and stream habitat along six rivers that flow into the Severn Sound by fencing, placing rip-rap along severely eroded portions of streambank, and planting shrubs and trees along valley areas retired from agriculture.

6. Background and Rationale

A 5-year Tributary Rehabilitation and erosion control Program was initiated in 1991 to address elevated levels of phosphorus entering Severn Sound from six river systems that flow through agricultural areas, and to restore fish and wildlife habitat. A project manager was hired to



SEVERN SOUND
REMEDIAL ACTION PLAN
Tributary Rehabilitation
Program

A project to improve water quality and to enhance fish and wildlife habitat, initiated in 1994, through a partnership with *THE LANDOWNER* and :

- **Great Lakes Cleanup Fund (Environment Canada),**
- **Jobs Ontario Fund (Ministry of Environment and Energy),**
- **Ontario Ministry of Natural Resources,**
- **Ontario Ministry of Agriculture, Foods and Rural Affairs and**
- **Community Volunteers.**

For more information, contact
the Severn Sound RAP at (705)-526-7809

Canada * Ontario

Figure 1. Tribulatry Rehabilitation Sign Draft.

implement the project. In year one, letters were sent to eligible landowners, introducing the program and inviting their participation on a voluntary basis. In subsequent years presentations were given to agricultural groups, volunteer groups, a display was set up at local fairs etc. Word-of-mouth from neighbour to neighbour was the best contact.

7. Regulatory Considerations

Work permits are obtained from the OMNR when needed; there is no Conservation Authority in the Severn Sound Watershed.

8. Criteria

Not available.

9. Project Design

Not available.

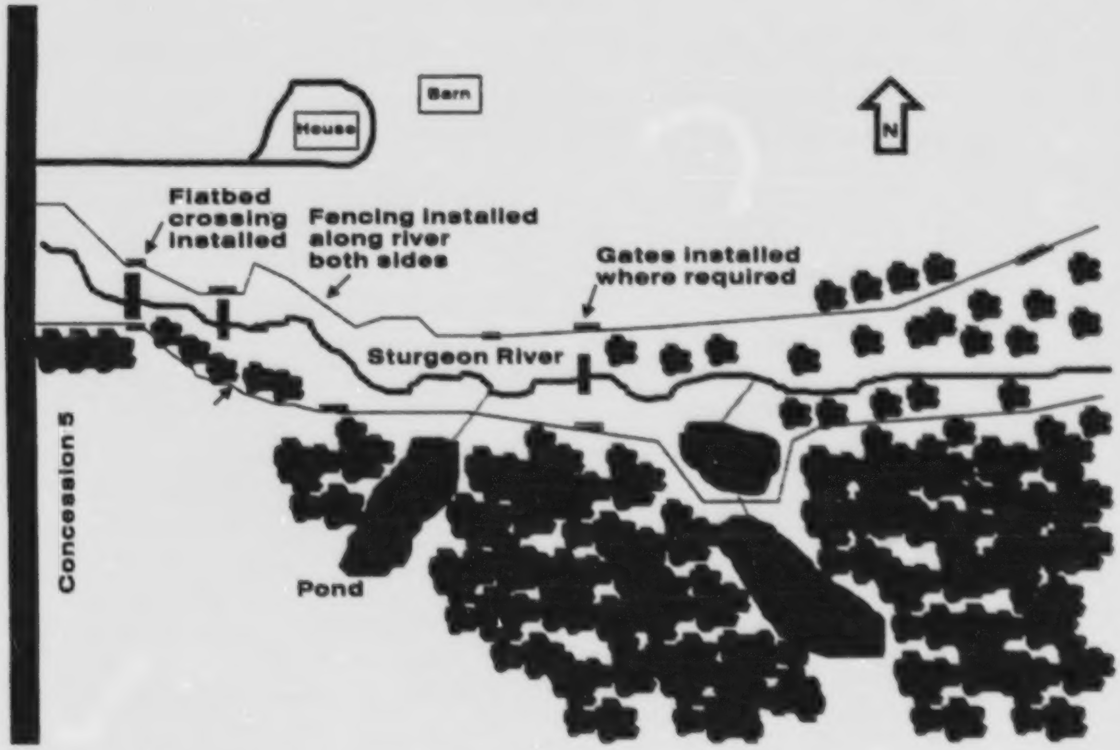

Barn
House
N
Flatbed crossing installed
Fencing installed along river both sides
Gates installed where required
Sturgeon River
Concession 5
Pond

Figure 2. Severn Sound RAP Tributary Rehabilitation Program, Farm Fencing Project Proposal, Oro-Medonte Twp.

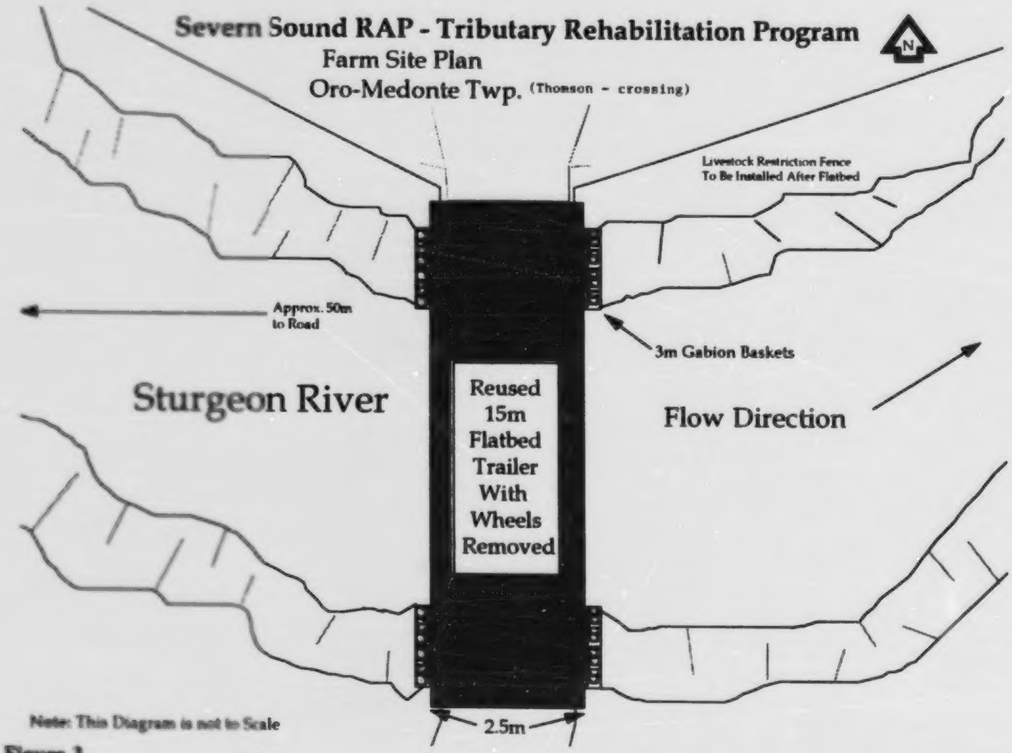

Severn Sound RAP - Tributary Rehabilitation Program
N
Farm Site Plan
Oro-Medonte Twp. (Thomson - crossing)
Livestock Restriction Fence
To Be Installed After Flatbed
Approx. 50m
to Road
3m Gabion Baskets
Sturgeon River
Reused
15m
Flatbed
Trailer
With
Wheels
Removed
Flow Direction
Note: This Diagram is not to Scale
2.5m

Figure 3.

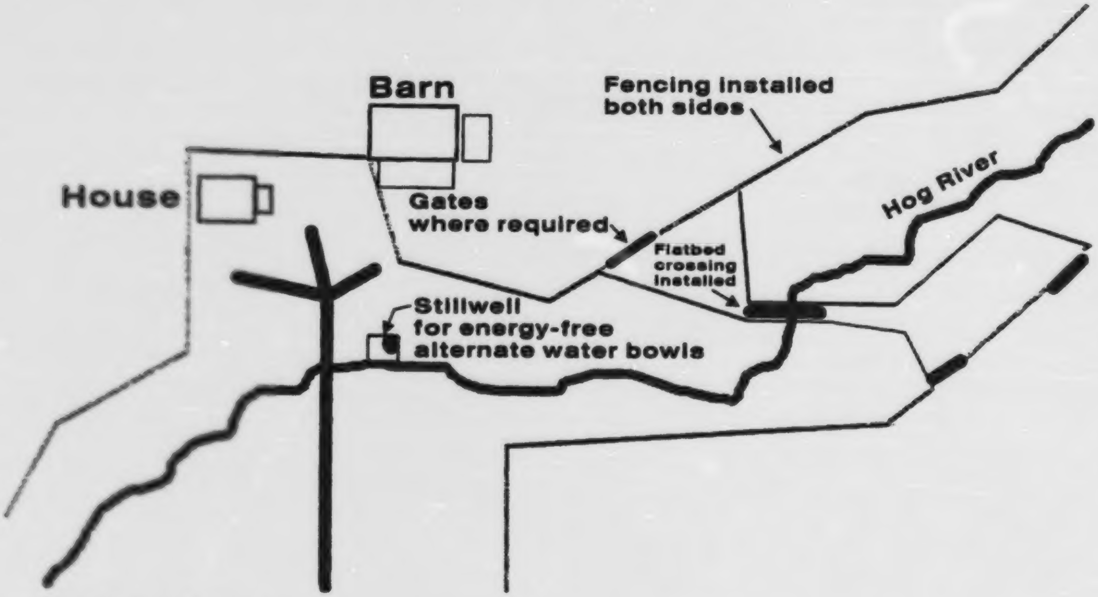
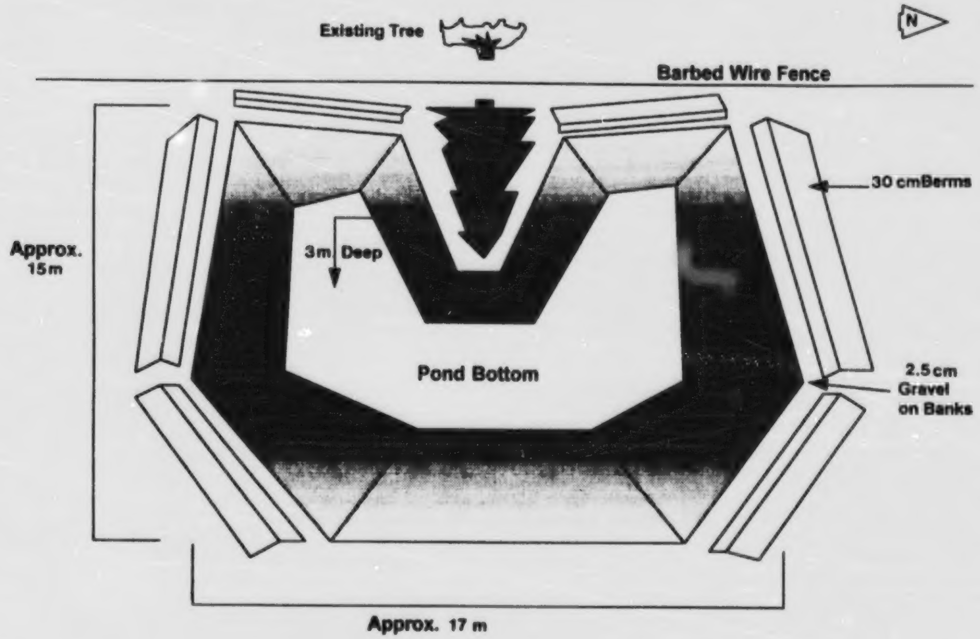
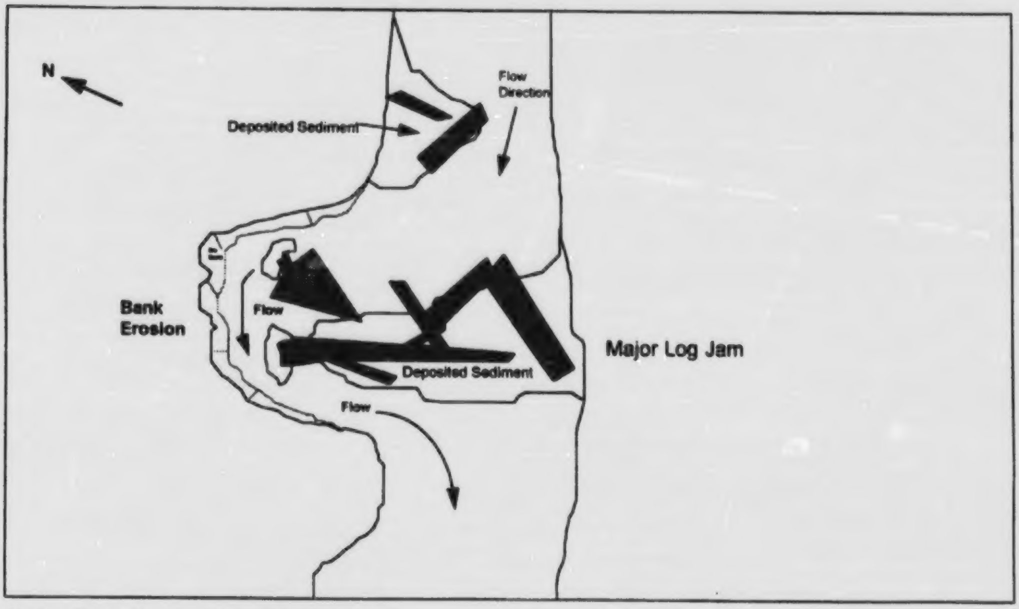

Barn
Fencing installed
both sides
House
Hog River
Gates
where required
Flatbed
crossing
installed
Stillwell
for energy-free
alternate water bowls

Figure 4. Farm location plan.


Existing Tree
N
Barbed Wire Fence
30 cmBerms
Approx. 15m
3m Deep
Pond Bottom
2.5cm Gravel on Banks
Approx. 17 m

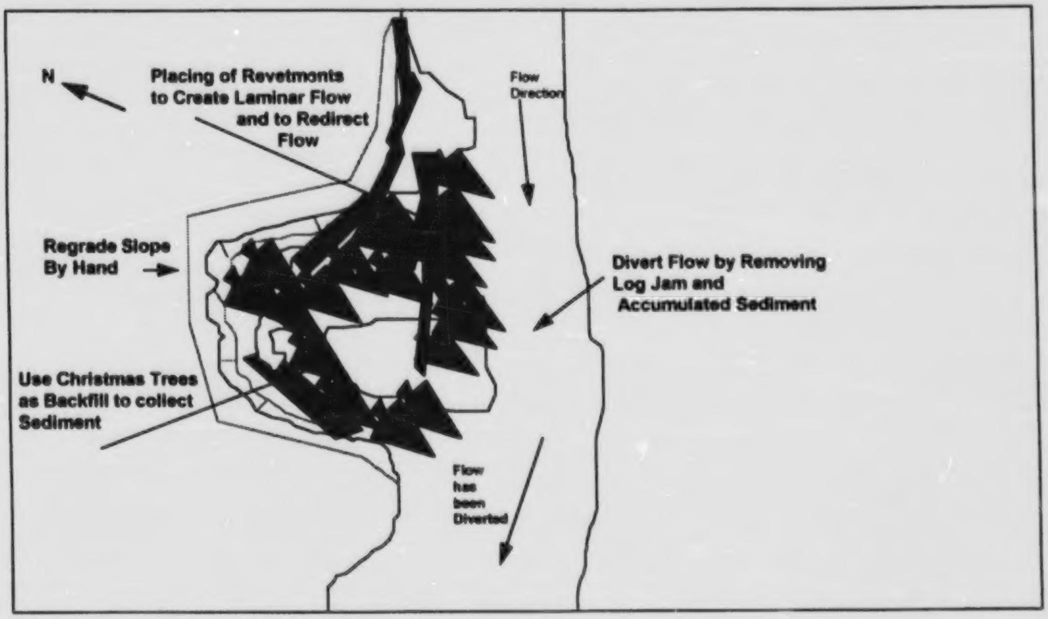
Not To Scale

Figure 5. Edwards Property – Proposed Alternate Water Source Pond.


N
Flow Direction
Deposited Sediment
Bank Erosion
Flow
Major Log Jam
Deposited Sediment
Flow

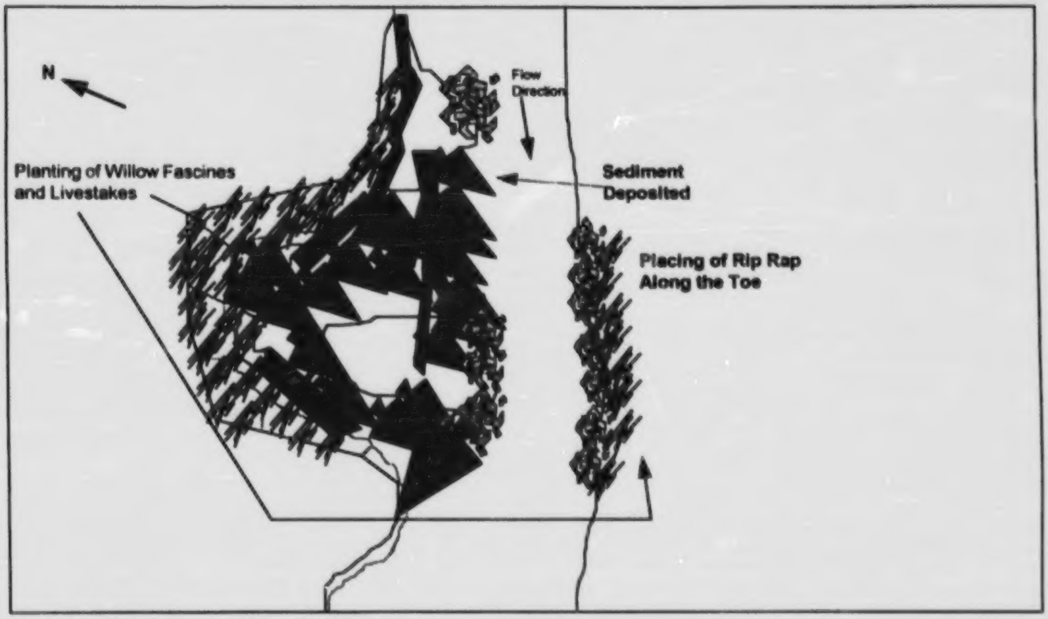
Note: This Diagram is not to scale

Figure 6. Erosion site on Hog Creek. Rotary Club Proposal (before erosion control).


N
Placing of Revetments to Create Laminar Flow and to Redirect Flow
Flow Direction
Regrade Slope By Hand
Divert Flow by Removing Log Jam and Accumulated Sediment
Use Christmas Trees as Backfill to collect Sediment
Flow has been Diverted

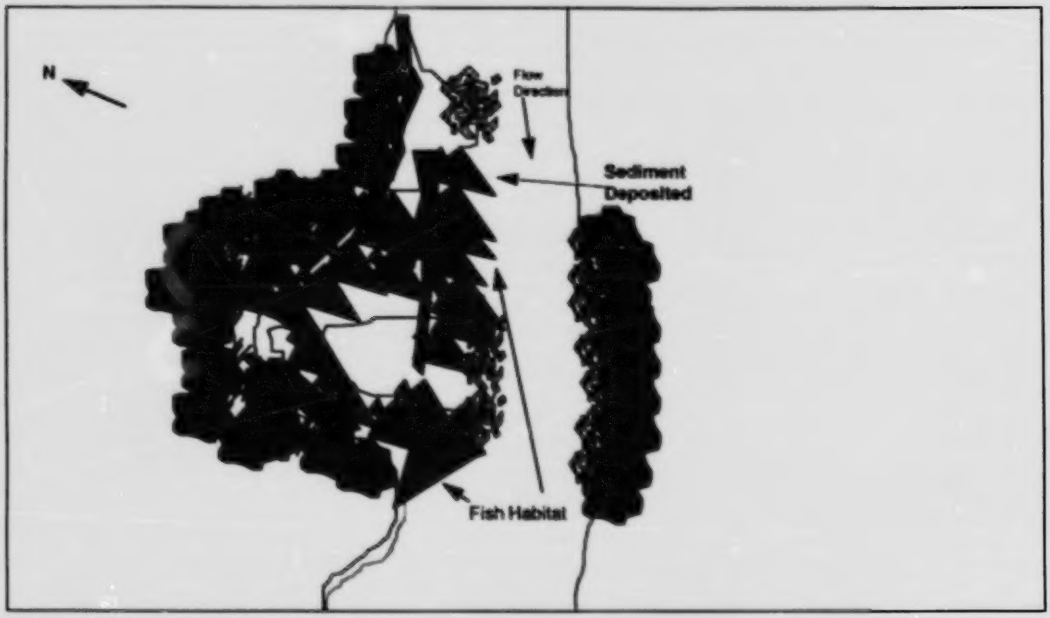
Note: This Diagram is not to scale

Figure 7. Erosion site on Hog Creek. Rotary Club Proposal (Phase 1: Erosion Control).


N
Flow Direction
Planting of Willow Fascines and Livestakes
Sediment Deposited
Placing of Rip Rap Along the Toe

Note: This Diagram is not to scale

Figure 8. Erosion site on Hog Creek. Rotary Club Proposal (Phase 2: Bioengineering).



Note: This Diagram is not to scale

Figure 9. Erosion site on Hog Creek. Rotary Club Proposal (final product).

10. Implementation

The rehabilitation sites of streambanks and stream habitat along six rivers that flow into the Severn Sound are located on any of the farms and rural lands within the watershed. Project participation is on a voluntary basis with priority given to sites that have the highest potential for stream improvement. To date, a combined total of 23 km of river (approx. 40 km of streambank) have been fenced denying access to more than 1350 livestock. Approximately 100 ha of land have been retired, over 38 000 trees and shrubs have been planted along valley lands by volunteers. Several eroded banks have been stabilized where required along several segments of the projects sites using 15 to 20 mm rip-rap and/or dogwood plantings. Rip-rap was placed by backhoe, directly on the eroded banks without filtercloth underneath in order to promote vegetation growth through the stone. Inspection three years after rock placement showed good results. Sixteen alternate water sources for livestock have been provided. These include sling pump, energy free water bowl, dug pond, tapping into existing wells, still well beside river and pasture nose pump. The type used depends upon the individual site and the setup of the farm operation. In addition 6 km of stream have had logjams removed by hand by Tiny Twp. students. Approximately 64 songbird nest boxes have been placed along the streams. It is important to have the landowner very involved in planning, choices etc. to ensure they "take ownership" of the project upon completion, and maintain any structures put in place. Each landowner is also informed as to other community involvement in cleanup actions, so that they do not feel targeted and become defensive.

11. Degree of Environmental Intervention

Minimal. Each site is negotiated individually, some of the buffer areas between the fence and the river may be narrower (3-5 m) than desired minimizing the desired effects on habitat, as compared to other wider valleys retired (30+m) which form excellent riparian corridors.

12. Cost

Yearly:
- Labour – approx 100k
- Materials – approx 50k
- In kind aid – 100K (labour, equipment, land retired, expertise, materials)
- Total approximately – **$250K** yearly

13. Biological Assessment

Photos were taken at each site before and after work was done to show changes. Bird surveys have been conducted to detect any use changes. Biomass monitoring is continuing in order to note any fish population trends. Water quality is monitored to record changes. Vegetation response is immediately visible in photos. Other monitoring may take longer to detect changes.

14. Measures of Success

Assessment is incomplete, but there are indications that the project has been successful. In some cases, substantial riparian corridors have been established where neighbouring farms have become involved with the program. Volunteers initiated a breeding bird monitoring program in 1994 on 5 project sites. Bird boxes are checked annually for species and occupancy rates.

1993 Site #1 Total boxes: 4
Bluebird nest in 1
Wren nest in 1

1994 Site #1 Total boxes: 4
Swallow nest in 1
Wren nest in 1
Site #2 Total boxes: 4
Swallow nests in 3

Site #3 Total boxes: 4
Bluebird nest in 1
Wren nests in 2

Site #4 Total boxes: 12
Bluebird nests in 2
Swallow nests in 6

Since 1992 survival of planted trees has ranged from 65 to 95%. Following installation of fences, all sites experienced immediate improved vegetative habitat. Fish biomass surveys are conducted annually at nine index stations throughout the effected watersheds. We also plan to monitor invertebrate and water temperatures, to assess aquatic habitat improvements. An estimated 190.5 kg/yr of Phosphorus has been prevented from reaching Severn Sound tributaries this year. The total Phosphorus load reduction to date has reached approximately 434 kg/yr. Reduced livestock health risks from water born diseases and hoof rot, and improved agricultural land values are also noted benefits. Improved barnyard management practices have lead to reduced contaminated runoff therefore improved surface water quality.

Success Rating: 1

15. Key References

Severn Sound Remedial Action Plan Stage 2 Report.

Correct citation for this contribution:

Craig, R. 1995. Severn Sound tributary rehabilitation and erosion control program, p. 112–120. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 17

1. Project Title: Underwater Fish Reef Creation Project within Ashbridge's Bay Park, City of Toronto

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3. Agencies Involved

Metro Toronto and Region Remedial Action Plan
Environment Canada's Great Lakes Cleanup Fund
Ministry of Environment and Energy
Ministry of Natural Resources, Maple District
Municipality of Metropolitan Toronto

4. Restoration Goal

To establish structural fish habitat, improve conditions for the resident fish community, and enhance technical knowledge associated with the creation of fish habitat.

5. Project Type

Creation of new fish habitat.

6. Background and Rationale

The nearshore substrates of the Metro Toronto waterfront area are essentially uniform, consisting mainly of sand, bedrock and fine materials. Habitat rehabilitation through the creation of nearshore reef structures offers interstitial refuge and vertical relief, as well as important structural habitat for waterfront fish communities. Located nearshore, habitat structures also offer increased urban angling and education opportunities.

Fisheries surveys between 1989 and 1992 identified 29 fish species within Ashbridge's Bay boat basin. The lack of physical structure, coupled with water quality concerns at this site, may be limiting fish production. An increase in the diversity of structural habitat is expected to benefit fish communities at this location.

An underwater fish reef was construction within the Ashbridge's Bay boat basin December 3-9, 1992.

7. Regulatory Considerations

A number of approvals from Federal, Provincial, and Municipal agencies were obtained to meet legislative requirements before conducting this project. The following outlines each Federal, Provincial, and Municipal agency involved in the approval process.

Federal

Environment Canada
- Summaries of Initial Assessment as per Federal Environmental Assessment Review Process

Department of Fisheries and Oceans
- Fisheries Act

Canadian Coast Guard
- Navigable Waters Protection Act

Provincial

Ontario Ministry of Environment and Energy
- Provincial Environmental Assessment Act (Ont. Reg. 205 8(2)(h), due to the project being a "Fish and Wildlife project")

Ontario Ministry of Natural Resources
- Fisheries Act
- Lakes and Rivers Improvement Act
- Public Lands Act

Municipal

Toronto Harbour Commission
- approval contingent upon THC receiving copies of finished work plans submitted to the Coast Guard.

Metro Parks and Property
- Waterfront Agreement, 1972

Metropolitan Toronto and Region Conservation Authority
- internal development project approval

8. Criteria

Danehy et al. (1991) noted that the growth rate of yellow perch and white perch (*Morone americana*) was greater for individuals captured over cobble/rubble shoals versus sandy sites. These authors indicated that the amount of available cover may influence growth rate based on energy expenditure differences for fish inhabiting different substrate types. The artificial reef structure was placed in an area of virtually featureless substrate to enhance fish productivity in nearshore waters.

MTRCA/OMNR summer electrofishing data shows a trend whereby a greater number of fish species are captured within sheltered boat basins having a diversity of habitats than exposed coastal location. The temperatures within these boat basin generally is 5°C warmer than outside. These findings are consistent with Portt and King (1991) who suggested that increased species richness might be attributable to environments with greater substrate diversity accompanied by appropriate water temperatures.

9. Project Design

The Ashbridge's Bay underwater fish reef was designed to provide structural relief and spatial diver-

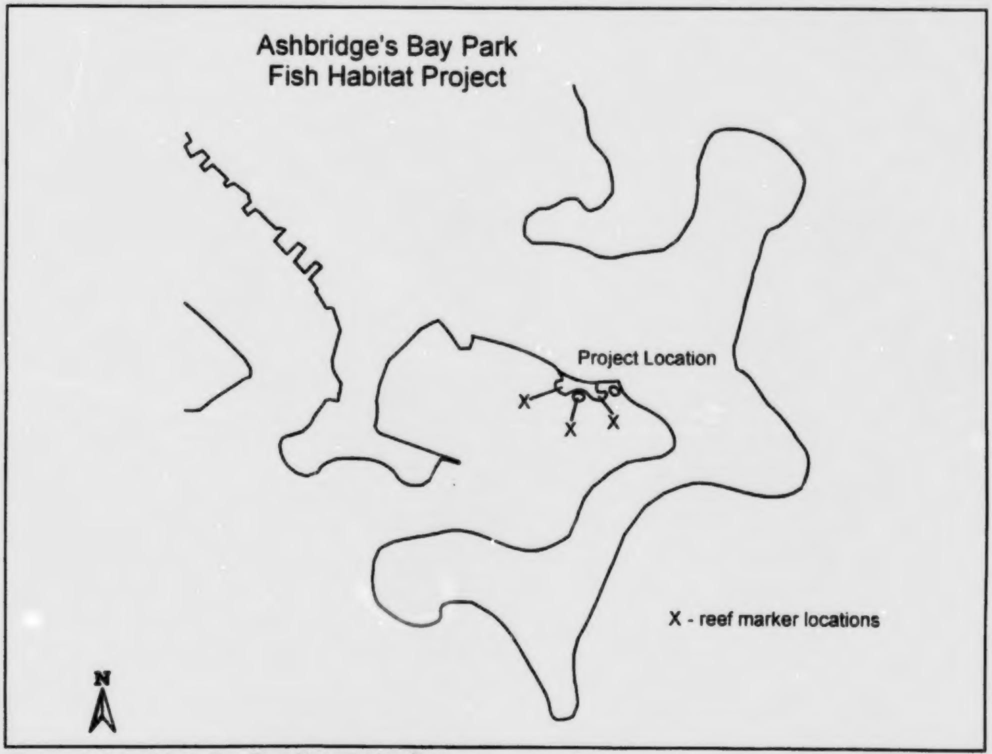

Figure 1. Ashbridge's Bay Park Fish Habitat Project.

sity within a relatively featureless basin (Figure 1). The reef was constructed in an irregular outline, centered on the 3 transects (Figure 1), conformed to the contours of the basin and maximized interstitial spacing and edge. Ecologically inert materials (natural aggregates) were selected.

The reef was designed to maximize:
- vertical relief
- irregular shape
- diversity of substrates
- interstitial spacing

The reef measures approximately 23.5 m from shore and is 30 m in length along the shoreline. It measures 2 – 2.5 m in height at the outside edge. The highest point of the reef is 1.0 m below datum.

10. Implementation

The project was completed between the 3rd and 9th of December, 1992. Advance planning and approvals took approximately six months. The substrate added was clean, silt-free stone. Aggregate materials were ordered 24 h in advance, with consideration being given to weather conditions (ie: rain/snow and temperature as it relates to ground conditions), progress in implementation at the construction site, numbers of trucks available for delivery by construction companies, and heavy equipment availability. Reef materials were transported to the site by triaxle/tandem trucks. Four rip-rap trucks with steel lined boxes were required. Trailers were not permitted on the site due to safety considerations associated with the small area for turning and wind conditions. This generally averted vehicles getting stuck or rolling over on soft ground.

Seasonal scheduling considerations

When scheduling the time for construction activity consideration was given to:
- Low water levels associated with late fall to facilitate the placing of aggregate materials. Water levels have been a key factor in establishing project priority concerning implementation, and,

- Frost conditions. Frost hardens the ground surface and makes it more suitable for movement of heavy equipment and for trucking materials. On most days the delivery of aggregate materials was made early in the morning. Preferred temperature conditions were below freezing and dry, to minimize the amount of damage to park lawns and asphalt.

Marking the perimeter of the reef

The reef perimeter was marked with temporary caution buoys to facilitate material placement. Reefs were regularly hand sounded to keep reef materials at 1.0 m below datum during construction. Anchored markers (Coast Guard approved) are deployed seasonally to indicate the boundaries of the reef.

Heavy Equipment

Heavy equipment used to build the reef included the use of a 977 CAT frontend loader and a Koehring 6644 backhoe. The Koehring 6644 backhoe was used for placing materials and sculpting the reef while the 977 CAT delivered materials to the backhoe. Onshore roads were required to safely move aggregate to the edge of the boat basin.

Construction

A platform was constructed in the boat basin to extend the backhoe's reach. The platform was constructed with rip rap covered with a surface layer of gabion to slightly above water level. This temporary platform was created by the 977 CAT and was later sculpted by the Koehring 6644 and incorporated into the reef.

A stable pad of gravel (5 cm clear) and gabion (7.5 – 25 cm) was created upon which the fish reef lies. Quarried rip rap stone (23 – 60 cm) irregular in shape forms the majority of the reef and lies halfway across the pad. Small outlying rubble piles resembling submerged islands have been created at the outside of the reef. These islands are contained within the underwater embayments of the reef.

The shoreline has been altered to provide habitat diversity and now show irregular shoreline features. At the shoreline interface, rip rap is covered with gabion stone (7.5 – 2.5 cm) and sprays of gravel (9 mm pea and 5 cm clear). Boulders (23 – 60 cm) have been placed in areas of gravel. Armour stone has been placed on the shore to provide platforms for angling. Filter cloth was been placed between materials of the reef and soft sediments of the shoreline to provide structural integrity.

The Ashbridge's Bay fish reef was created in waters with a maximum depth of 3.5 m (relative IGDL datum, 74.005 a.s.l.). The constructed reef covers an area of soft sediments. Aggregate materials were set to a height of up to 2 m above the original bottom substrates. Aggregate material used to complete the fish reef occupies approximately 400 m^3.

11. Degree of Environmental Intervention

Morphometry and substrate characteristics were primarily affected. Off-site sediments within the boat basin were not disturbed during construction. No mortality of fish was observed. Construction was in December to minimize environmental impacts and disturbance to the resident fish community.

December construction limited impacts to park use and destruction of grounds by heavy equipment travel.

12. Costs

Planning and approvals*	$20 000.00
Materials:	$15 544.44
Labour (heavy equipment):	$ 7 993.44
Monitoring (5 yrs):	$ 10 000.00
Total costs:	**$53 537.88**

*While approximately only 2 months worth of actual work time was required for project planning and approval the overall process took approximately 6 months and required daily attention.

13. Biological Assessment

The MTRCA undertakes a Waterfront Monitoring Program across the Metropolitan Toronto waterfront. From this program, baseline monitoring data exists for the Ashbridges Bay boat basin for the following parameters: water quality, sediment quality, benthic invertebrate communities, fisheries communities. Fish community assessment is done in cooperation with OMNR using the SR-20 electrofishing boat. Monitoring of these parameters will continue within the boat basin with special interest being paid to the underwater reef location. Methodologies used for this monitoring program are outlined in, *Toronto Waterfront Habitat Rehabilitation Pilot Projects, Technical Report: 1992*, available through the MTRCA and *1989 -- 1993 Toronto Waterfront Fish Communities: Summary and Assessment*, available through Ministry of Natural Resources, Greater Toronto and Area District.

14. Measures of Success

If diversification of the substrates within Ashbridge's Bay boat basin is successful a corresponding increase in the abundance of fish found within the boat basin and an increase in the number of YOY fish is expected. Ultimately these increases will assist in achieving the Toronto RAP goals of a more diverse and healthy fish community along the Toronto waterfront.

Success Rating: 1 – assessment incomplete

An accurate understanding of the effect of this project on the resident fish community will not be available for five years. Electrofishing has shown an accumulation of fish within the vicinity of the reef, indicating that it may be providing improved habitat.

15. Key References

Danehy, R.J., Reingler, N.H., and Gannon, J.E. 1991. Influence of nearshore structure on growth and diets of yellow perch (*Perca flavescens*) and white perch (*Morone americana*) in Mexico Bay, Lake Ontario. J. Great Lakes Res. 17(2):183-193

MTRCA, 1992. Toronto Waterfront Habitat Rehabilitation Pilot Projects. Technical Report: 1992. (Internal publication)

Portt, C.B., and King, S.W. 1991. Fish community structure, abundance, and biomass along three southern Ontario breakwaters and in adjacent reference habitats. Cam Portt and Associates, Waterloo, Ont.

Strus, R., 1994. 1989 – 1993 Toronto Waterfront Fish Communities: Summary and Assessment. Ontario Ministry of Natural Resources, Greater Toronto and Area District.

Correct citation for this contribution:

Vincent, J. 1995. Underwater fish reef creation project within Ashbridge's Bay Park, City of Toronto, p. 121–127. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 18

1. **Project Title: Col. Samuel Smith Waterfront Park Bass Spawning Area**

2. **Contact**

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3. **Agencies Involved**

Metropolitan Toronto and Region Conservation Authority
Environment Canada's Great Lakes Cleanup Fund
Ontario Ministry of Environment and Energy
Ontario Ministry of Natural Resources
Municipality of Metropolitan Toronto

4. **Restoration Goal**

To create smallmouth bass spawning areas within the northerly wetland of Col. Samuel Smith Park.

5. **Project Type**

Creation of new habitat

6. **Background and Rationale**

Historically, wetlands were viewed as wastelands that were to be filled for agricultural or urban development. An estimated 832 ha of coastal wetlands once existed within the Metropolitan Toronto area. Today, only 93 ha remain and attitudes towards wetlands have changed. They are now viewed as being an important component of a healthy environment; important not only for wildlife, but humans as well.

The Col. Samuel Smith Waterfront Park is situated on the shoreline of Lake Ontario at the base of Kipling Avenue, within the City of Etobicoke. In the Revised Master Plan dated April 3, 1992, the most significant modification was the replacement of a swimming lake with a marsh/wetland component.

The creation of the marsh/wetland is in keeping with MTRCA's *Lake Ontario Waterfront Regeneration Project for 1992 – 1994.* This natural habitat initiative is part of additional regeneration efforts for Col. Samuel Smith Park including fisheries habitat and terrestrial habitat. The

Royal Commission of the Future of the Toronto Waterfront suggested in their *Shoreline Regeneration Report* that "efforts to create habitat such as wetlands should be actively supported in the Greater Toronto Bioregion Shoreline Plan." The Metro Toronto and Region Remedial Action Plan has identified a target of increasing the biomass of piscivorous fish species to levels above 20% of the total resident fish biomass.

The creation of bass spawning habitat will increase recruitment within the Col. Sam Smith Waterfront Park vicinity of Lake Ontario, increasing the biomass of piscivorous fish across the Toronto waterfront.

7. Regulatory Considerations

This project was considered under the Environmental Assessment Act for the Col. Sam Smith Revised Master Plan and approved by the Ministry of Environment and Energy.

A number of approvals from Federal, Provincial, and Municipal agencies are required to meet legislative requirements before conducting this project. The following outlines each Federal, Provincial, and Municipal agency involved in the approval process.

Federal

Environment Canada
- Summaries of Initial Assessment as per Federal Environmental Assessment Review Process

Department of Fisheries and Oceans
- Fisheries Act

Provincial

Ontario Ministry of Environment and Energy
- Provincial Environmental Assessment Act

Ontario Ministry of Natural Resources
- Fisheries Act
- Lakes and Rivers Improvement Act
- Public Lands Act

Municipal

Metropolitan Toronto Parks and Property
- Waterfront Agreement 1972

Metropolitan Toronto and Region Conservation Authority
- Internal development project approvals

8. Criteria

According to Scott and Crossman (1973), smallmouth bass build nests in areas with a sandy or rock bottom near the protection of logs or boulders. Productivity and recruitment is dependant on thermally stable waters and the proximity of aquatic vegetation for foraging by fry and juvenile fish.

9. Project Design

Three bass spawning shoals approximately 3 m^2 in size were constructed in the permanent water channel on the south side of the island, adjacent to the seasonally flooded area. The spawning areas are located close to shore, adjacent to emergent and floating aquatic vegetation, and in the protected less exposed ares of the wetland. The spawning areas will be exposed during average low water conditions, this will preserve the substrate conditions by discouraging colonization by plants.

10. Implementation

The Koering backhoe created a stable foundation using a mixture of pea sized gravel and sand. This was placed in the water covering an area of roughly 3 m^2. Three or four pieces of irregularly shaped armour stone were then placed on the pea gravel/sand pad. The boulders will provide additional protection to redds and will maximize the productive potential of the spawning area by

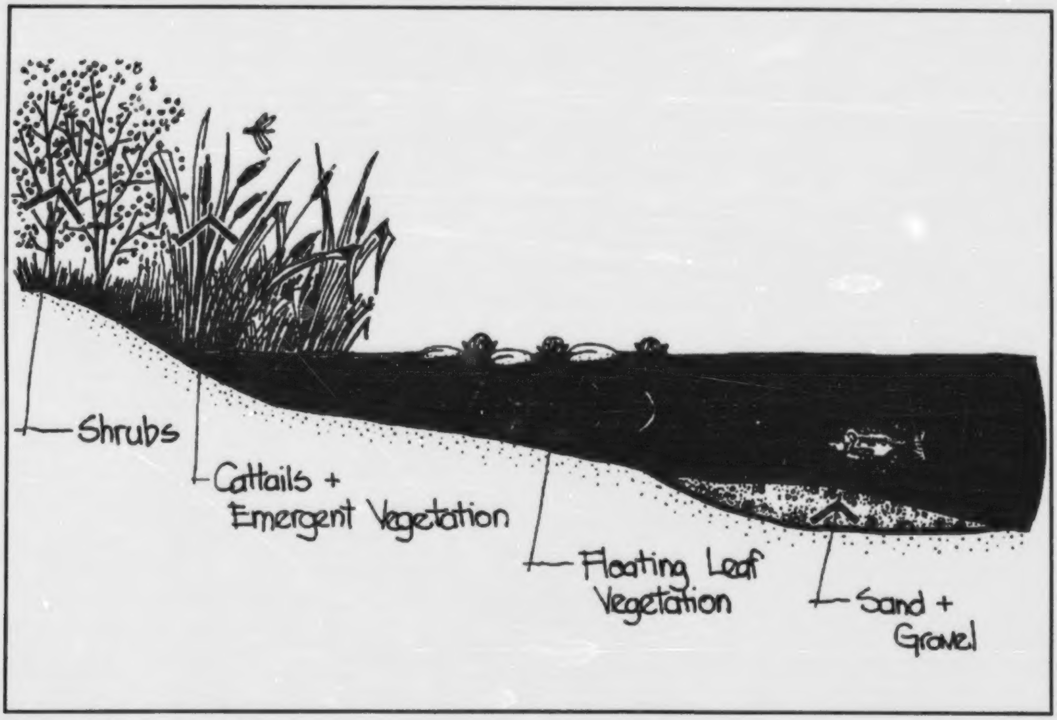

Figure 1. Bass spawning habitat.

providing a visual barrier between adult fish. While these areas are intended for smallmouth bass, many species of resident fish will potentially make use of these shoals.

11. Degree of Environmental Intervention

The area in which the bass spawning shoals were placed was excavated from lakefill to create permanent water and seasonally flooded zones. Therefore, the degree of environmental impact was isolated from fish and wildlife activities.

The excavation of the site was completed "in the dry", limiting the affects of excavation on the surrounding fish and wildlife communities.

12. Cost

Design & supervision:	$1 500
Materials:	$600
Construction:	$500
Monitoring:	$1 000
Total:	**$3 600**

13. Biological Assessment

Fish seining inventories completed in July and September 1994 indicated the area colonized by smallmouth bass, northern pike, and various types of sunfish and minnows. Fish age classifications included mature adult, juvenile, and young of the year. These results show that fish colonization and recruitment is occurring, indicating successful habitat creation.

Future monitoring of the site is expected to show increased recruitment and fish species diversity.

14. Measures of Success

Basic construction was completed in November 1993. Fish access to the entire site was grant with the removal of barriers in June 1994. Therefore, assessment results are preliminary. Further monitoring is required. Initial results show the area being colonized and show recruitment of smallmouth bass occurring.

Success Rating: 1 – assessment incomplete

15. Key References

Scott, W.B., and Crossman, E.J. 1973. Freshwater Fishes of Canada. Fish. Res. Board Can. Bull. 184: 996 p.

Strus, R., 1994. 1989 - 1993 Toronto Waterfront Fish Communities: Summary and Assessment. Ontario Ministry of Natural Resources, Greater Toronto and Area District.

Vincent J, 1992. Toronto Waterfront Habitat Rehabilitation Pilot Projects. Technical Report: 1993. Metropolitan Toronto and Region Conservation Authority.

Correct citation for this contribution:

Vincent, J. 1995. Col. Samuel Smith waterfront park bass spawning area, p. 128–132. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 19

1. Project Title: Wetland Plantings Within the Mimico Creek Estuary, Humber Bay Park, City of Etobicoke

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3. Agencies Involved

Metro Toronto and Region Remedial Action Plan
Environment Canada's Great Lakes Cleanup Fund
Ministry of Environment and Energy
Ministry of Natural Resources
Municipality of Metropolitan Toronto

4. Restoration Goal

To establish a diverse and healthy wetland plant community within the Mimico Creek Estuary. To evaluate different planting techniques and wetland plant species, determining the most appropriate methods.

5. Project Type

Creation of new habitat.

6. Background and Rationale

Wetlands represent a very small percentage of our total land area, yet they provide a haven for an unusually large percentage of our plants, birds and wildlife. One third of North American bird species, for example, appear to rely directly on wetlands for some resource.

Coastal wetlands are a critical component of the Lake Ontario shoreline providing habitat for fish and wildlife. Historically, most rivers within Metro Toronto supported estuary wetlands, the successful recreation of these river mouth marshes will be critical in the restoration of degraded Great Lakes habitat.

The Mimico Creek estuary has been altered by urbanization, currently residing within the lakefilled Humber Bay Park in the City of Etobicoke. The wetland project is located within an embayment immediately south of Lakeshore Blvd. on the west side of the creek. Factors that appear to be limiting natural colonization include turbidity, lack of seed stock, fluctuating lake levels, ice shear, and wildlife predation. It is believed that once a community is established, it will be able to withstand these pressures. A plant establishment program began in August of 1992 and was completed in the fall of 1993.

7. Regulatory Considerations

A number of approvals from Federal, Provincial, and Municipal agencies were obtained to meet legislative requirements before conducting this project. The following outlines each Federal, Provincial, and Municipal agency involved in the approval process.

Federal
Environment Canada
- Summaries of Initial Assessment as per Federal Environmental Assessment Review Process

Department of Fisheries and Oceans
- Fisheries Act

Provincial
Ontario Ministry of Environment and Energy
- Provincial Environmental Assessment Act

Ontario Ministry of Natural Resources
- Fisheries Act
- Lakes and Rivers Improvement Act
- Public Lands Act

Municipal
Metropolitan Toronto Parks and Property
- Waterfront Agreement 1972

Metropolitan Toronto and Region Conservation Authority
- internal development project approvals

8. Criteria

Initial preference should be given to those wetland plant species that can withstand more rigorous environmental conditions (eg., *Typha* sp.). These plants will create the more sensitive environment needed support a more diverse plant community. Once these plants are established, more environmentally sensitive material can be planted.

Ideal emergent planting conditions include:

- water levels less than 30 cm
- enriched soils
- areas of reduced current
- isolated from predation by carp or waterfowl (can be achieved through fencing)

9. Project Design

Three different planting methods were examined: crib, fibre pot and free plantings. In 1992, one nearshore enclosure (#1) was planted with equal numbers of all three methods. One offshore enclosure (#2) was planted with all three methods. Two additional offshore enclosures (#3 & 4) were planted with free plants (Figure 1).

10. Implementation

Orange snow fence (0.9 m high) was installed at the site. This installation outlined the work area and offered protection from predation by carp and waterfowl. The fenced area was kept small to inhibit take-off and landings by Canada Geese.

Cedar triangular cribs were built in two sizes. The larger used 1.8 m × 20 cm logs, the smaller used 1.2 m × 20 cm logs. Eight large and seven small cribs were installed within enclosure 1. Large cribs were arranged flush to the fence with small cribs placed between larger ones. T-bars, nails and wire were used to secure cribs to the ground. T-bars were pounded into sediments below water levels. Securing these cribs to the ground proved very difficult. The buoyancy of the cedar material was very high. Eventually, all cribs were submerged.

Cattails, soft-stem bulrush, barberpole sedge, and arrowhead were collected from donor sites within the Metro Toronto vicinity from mid June to late September. Plants were collected by digging "plugs" using shovels. These "plugs" included as much root and associated soils as possible. "Plugs" were placed in fibre pots or large buckets with water for transport.

"Out of ground time" for the transplants was a maximum of 2 h. At Mimico Creek, an area was dug within the cribs or sediments large enough to accommodate the "plug" or fibre pot. The fibre pots were filled with sediment and the pot planted to a depth of 3/4 its height. All species were planted in the same manner.

11. Degree of Environmental Intervention

The areas planted were isolated from predation using snow fence. This restricted access to these areas by larger fish and waterfowl. It only slowed/reduced the access of mammals.

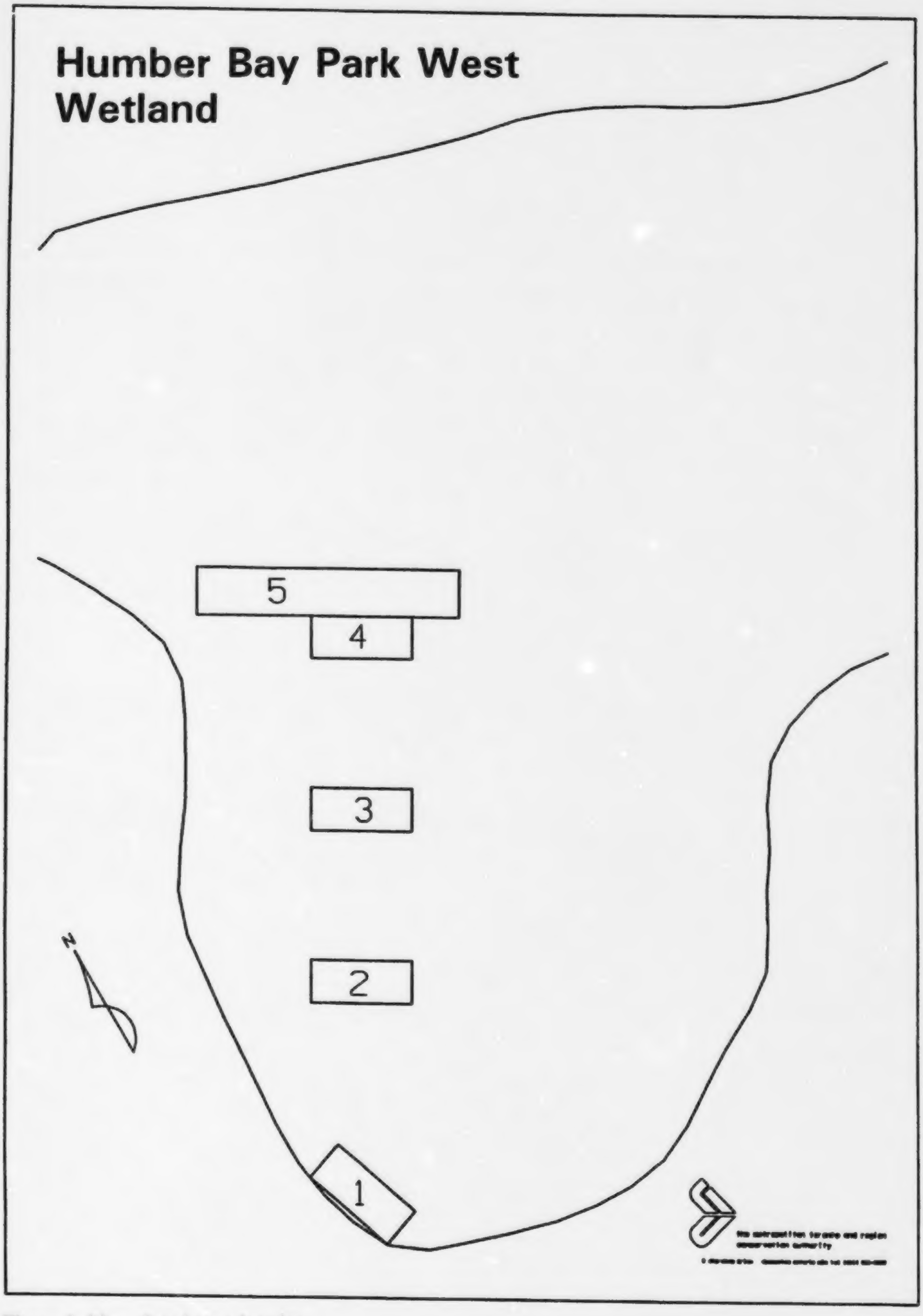
Humber Bay Park West
Wetland
5
4
3
2
1
N

Figure 1. Map of enclosure location.

12. Cost

4 EYC Crew (8 weeks/yr: 2 years):	$20 000
Vehicle & fuel:	$2 000
Materials:	$3 000
Project management(2 years):	$12 000
Monitoring (1wk/yr, 5 years)	$6 000
Total Estimated Project cost:	**$43 000**

13. Biological Assessment

An assessment of material survivorship and propagation was completed one year after planting. Frost and ice through the winter of 1992 resulted in lifting the t-bars holding fences and cedar cribs by roughly 1 m above high water levels, and lifted potted materials from the substrates. While the free plants suffered damage due to a harsh winter and high spring water levels, they survived in greater numbers than either other method.

As water levels receded, plant growth increased. As plants broke the water surface they tended to have a silt film covering them. Suspended sediments within the water column may be restricting plant growth potential. Investigation was initiated into the detailed hydrology and sedimentation of the estuary of Mimico Creek and how it may affect the wetland site.

Plants that survived and propagated included cattails (*Typha* sp.), arrowhead (*Sagittaria latifolia*) and soft stemmed bulrush (*Scirpus validus*). There was no sign in 1993 or 1994 of barberpole sedge (*Scirpus rubrotinctus*). Based on these observations initial wetland plant community establishment has been emphasizing cattail, soft-stemmed bulrush , and arrowhead species.

As a result of isolating planting areas an increase in species, number and vigor of naturally occurring wetland plants occurred. Giant burreed (*Sparganium eurycarpon*) and arrowhead (*Sagittaria latifolia*) increased in numbers and size within Enclosure 1 indicating that predation by waterfowl was a factor limiting growth.

Two years after planting, material showed increased propagation. Enclosure areas were more densely established with material expanding beyond the enclosure boundaries. Cattails did not produce seed in 1993 but did in 1994 (Table 1).

Total area of new habitat created is 402 m^2.

Table 1. Summary of Wetland Plant Growth (1992-1994): Mimico Creek Wetland Creation Project.

	Typha sp.	*Scirpus* sp.	*Sagittaria* sp.	*Alisma* sp.	*Sparganium* sp.
Total Planted	2145	132	62	0	0
Total Grown	2679	372	204 (54)	22	250
% Change	124.9%	281.8%	329% (87%)		

14. Measures of Success

Due to a harsh 1992 winter and very high water levels in the spring of 1993, the first years results were disappointing. Evaluation of plant establishment in 1994 showed good survivorship and extensive propagation. The variation in plant community establishment between years one and two shows the need for long term evaluation. Monitoring of this site will continue.

Success Rating: 4 – successful

15. Key References

MTRCA, 1993. Toronto waterfront habitat rehabilitation pilot projects, Technical Report, 1992.
MTRCA, 1994. Toronto waterfront habitat rehabilitation pilot projects, Technical Report, 1993.
Stabb, M., 1988. Wetlands Conservation on a small scale: The beaver baffler and other micro-management projects on private lands. Wetlands: Inertia or Momentum, Conference Proceedings. Federation of Ontario Naturalists, Don Mills, Ontario. pp 94-96.

Correct citation for this contribution:

Vincent, J. 1995. Wetland plantings within the Mimico Creek estuary, Humber Bay park, city of Etobicoke, p. 133-138. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 20

1. Project Title: Toronto Islands Northern Pike Spawning Habitat

2. Contact

Jennifer Vincent
Metropolitan Toronto and Region Conservation Authority
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Tel.: (416) 661-6600 ext. 349; FAX: (416) 661-6898

3. Agencies Involved

Metropolitan Toronto and Region Conservation Authority
Environment Canada's Great Lakes Cleanup Fund
Ontario Ministry of Environment and Energy
Ontario Ministry of Natural Resources
Municipality of Metropolitan Toronto

4. Restoration Goal

To improve northern pike habitat within the Toronto Islands by creating spawning habitat. To evaluate the feasibility of constructed northern pike spawning habitat.

5. Project Type

Creation of new habitat.

6. Background and Rationale

Historically, the Toronto Islands fish community has been seriously affected by urbanization and alteration to the natural island structure. As wetlands and seasonally flooded areas were filled, northern pike spawning, nursery and feeding areas were destroyed. Today the most diverse and populated fish community across the Toronto waterfront exists within the Toronto Islands vicinity.

In 1968, a section of the Toronto Islands lagoon known as Lighthouse Channel was partitioned off with an earth and rubble berm to create a "put and take" trout pond. The pond area contained extensive shallow, weedy areas. In order to maintain trout habitat, cold water was pumped in and regular weed removal was required. As years progressed, the cost of maintaining the pond outweighed its benefits. In an examination of other options, this area was recognized as having tremendous warmwater fish habitat potential, especially for northern pike. In 1992, as part of the Metropolitan Toronto Habitat Rehabilitation Pilot Projects program, the barrier-berm isolating the pond was breached at three points, providing the Toronto Islands fish community with access to valuable habitat.

Since breaching the berm, the additional habitat provided has increased spawning, nursery and feeding areas for an increased variety of fish species. By making the pond contiguous with the lagoon, the shoreline area is now subject to seasonal flooding. This has restored natural shoreline conditions and has the potential to provide valuable pike spawning habitat.

7. Regulatory Considerations

A number of approvals from Federal, Provincial, and Municipal agencies were obtained to meet legislative requirements before conducting this project. The following outlines each Federal, Provincial, and Municipal agency involved in the approval process.

Federal
Environment Canada
- Summaries of Initial Assessment as per Federal Environmental Assessment Review Process

Department of Fisheries and Oceans
- Fisheries Act

Provincial
Ontario Ministry of Environment and Energy
- Provincial Environmental Assessment Act

Ontario Ministry of Natural Resources
- Fisheries Act
- Lakes and Rivers Improvement Act
- Public Lands Act

Municipal
Metropolitan Toronto Parks and Property
- Waterfront Agreement 1972

Metropolitan Toronto and Region Conservation Authority
- Internal development project approvals

8. Criteria

According to Scott and Crossman (1973), ideal northern pike spawning habitat consists of seasonally flooded areas of soft grasses, bulrushes, and vegetative debris adjacent to a relatively warm weedy bay. Reid (1990) recommends the ratio of flooded area to weedy bay be 0.25. Other fish species benefitting from this type of habitat include largemouth bass and bluegill.

9. Project Design

To create shallow, seasonally flooded channels, projections (fingers) were made into the pond. These projections are designed at varying heights thereby being at varying depths when flooded. The idea behind this design is to create a variety of conditions that can provide habitat at a variety of water depths. The created channels vary in shape and sinuousity. This creates several quiet water areas as well as wave susceptible areas. Figure 1 is a conceptual diagram of the design.

10. Implementation

Silt curtains were used to mark off the work area and reduce the effects of sedimentation. Movement of the sediments after the project was complete was negligible.

The sand and compost materials required for the project were supplied by Metro Parks and Property, Toronto Islands Division from their stocked supply. Sand originated from dredging within the Toronto Islands.

To create shallow channels, five fingers were made into the pond. Sand was delivered to the site with a dozer pushing it into the water. This created a 6 m wide finger into the pond. Five evenly

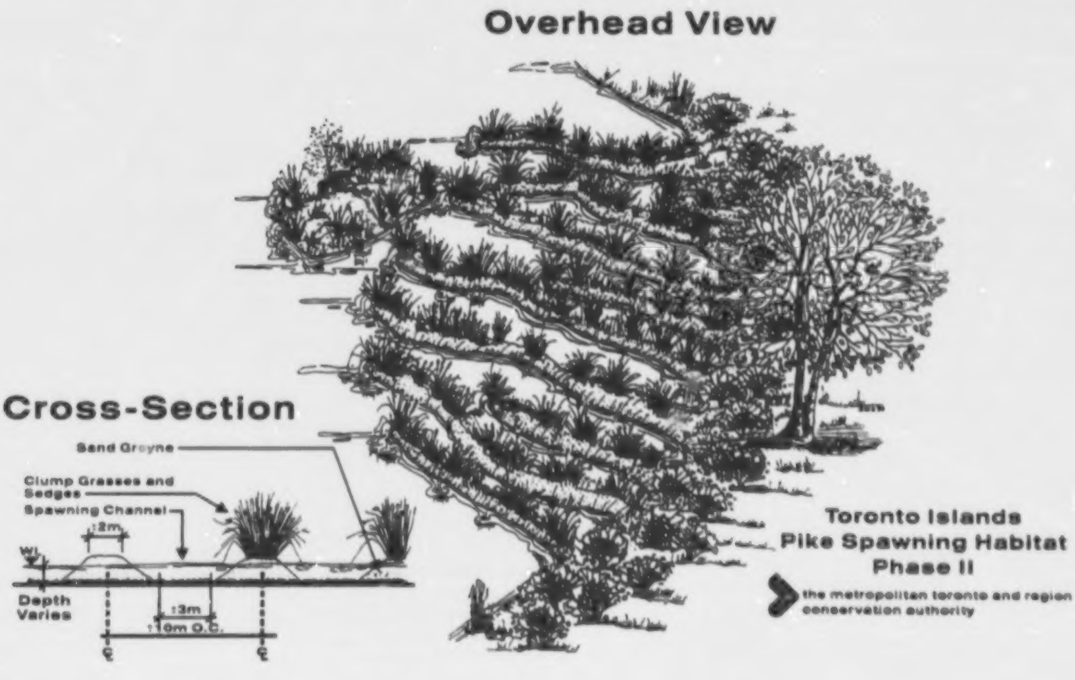
Overhead View
Cross-Section
Sand Groyne
Clump Grasses and Sedges
Spawning Channel
±2m
WL
Depth Varies
±3m
±10m O.C.
℄
℄
Toronto Islands
Pike Spawning Habitat
Phase II
the metropolitan toronto and region conservation authority

Figure 1. Waterfront Habitat Rehabilitation.

spaced fingers were created in this manner.

Once the initial fingers were created, a backhoe carved out the centre of each. This created two projections approximately 2.5 m wide at the water interface with the carved area at a shallower depth than the surrounding area. By carving out the centre of the finger, quiet backwater areas were created. These areas will be protected when flooded and offer warmer water.

Sand was augmented with compost. The compost was mixed into the sand to a depth of approximately 40 cm. Two types of commercial grass mix were chosen to seed the area. Tables 1 and 2 list the contents of each mix. Augmenting the commercial mixes was hand collected sedge seed, tolerant of seasonally flooded areas. The newly created fingers were stabilized using coconut fibre matting (Coir 900). In the spring of 1994 this area was hydroseeded.

The base of the fingers and the adjacent shoreline were densely planted with red osier dogwood, gray dogwood, nannyberry, and silverberry. These plantings will provide detritus for the spawning areas, additional wildlife habitat and restrict public access.

Table 1. Commercial Groundcover Grass.

Amount	Species
10%	white clover
15%	fiesta II perennial rye
25%	mustang tall fescue
10%	creeping red fescue
15%	victory chewing fescue
10%	bronco Kentucky bluegrass

Table 2. Commercial Wetland Grass.

Amount	Species
10%	red clover
10%	white clover
15%	birdsfoot trefoil
10%	alsike clover
15%	creeping red fescue
10%	highland colonial bentgrass
8%	nugget Kentucky bluegrass
10%	fiesta perennial rye
12%	*Poa trivialis*

11. Degree of Environmental Intervention

The morphometry of the site was altered increasing topographical relief. Sediment created due to construction was restricted by fences.

Fall construction limited impacts to fish and wildlife and to public use of the park.

12. Cost

Construction:	$24 600
Materials:	$5 200
Planning/supervision:	$10 350
Monitoring (5yrs)	$5 000
Total	**$45 150**

13. Biological Assessment

Electrofishing results after the berm was breached indicated a significant increase in species richness and biomass. A total biomass of 12.3 kg/ha is 869% higher than the prebreaching biomass.

In the spring of 1994 northern pike density within the pond was equal to that of the surrounding area. Vegetation on the newly created northern pike spawning "fingers" was incomplete. No active spawning was observed this year. Within the 1995 year vegetation establishment will be complete and it is expected that spawning pike will be observed and young-of-the-year pike found during fall electrofishing surveys.

14. Measures of Success

Initial results from breaching the berm to provide access to habitat has shown the need for shallow, weedy, bay habitat within the Toronto Islands. The addition of northern pike spawning areas within this new habitat has not been fully evaluated.

Success Rating: 1 – assessment incomplete

15. Key References

MTRCA, 1992. Toronto Waterfront Habitat Rehabilitation Pilot Projects. Technical Report: 1992. (Internal publication.)

Reid, K.B. 1990. Status of the pike (*Esox lucius* L.) in Lake Wilcox, Ontario and rehabilitation of its spawning habitat by marsh creation. M.Sc. Thesis, Trent University, Peterborough, Ontario.

Scott, W.B., and Crossman, E.J. 1973. Freshwater Fishes of Canada. Fish. Res. Board Can. Bull. 184: 996 p.

Vincent J, 1992. Toronto Waterfront Habitat Rehabilitation Pilot Projects. Technical Report: 1993. Metropolitan Toronto and Region Conservation Authority.

Wainio, A., Smitka, J., Veitch, I., Jones, M., and Kaszuba, A. 1973. A fish survey of the Toronto Islands. Ontario Ministry of Natural Resources.

Correct citation for this contribution:

Vincent, J. 1995. Toronto Islands nothern pike spawning habitat, p.139–144. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 21

1. Project Title: Metzger Marsh Coastal Wetland Restoration Project

Metzger Marsh Wildlife Area/Ottawa National Wildlife Refuge on the south shore of the western basin of Lake Erie, Ohio.

2. Contact

Gildo Tori, Project Leader
Crane Creek Wildlife Research Station , Ohio Division of Wildlife, 13229 W. SR 2,
Oak Harbor, OH 43449
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3. Agencies/Partners Involved

Ohio Division of Wildlife, 13229 W. SR 2 , Oak Harbor, OH 43449
USFWS-Ottawa National Wildlife Refuge, 1400 W. SR 2, Oak Harbour, OH 43449
Ducks Unlimited, Southern Regional Office, 101 Business Park Dr., Jackson, MS 39213
National Biological Survey- Ann Arbor, MI
ODNR-Division of Geological Survey
Maumee Valley Audubon Society
Lake Erie Waterfowlers
Ohio Decoy Carvers and Collectors
Wolf Creek Sportsmens Club
Mr. Herbert Metzger
Bluffton Sportsmens Club

4. Restoration Goal

To protect, restore and intensively manage 368 ha of lacustrine emergent coastal wetland while providing, to the extent possible, that the widest spectrum of benefits associated with this wetland be enhanced.

5. Project Type

Restoration and protection of coastal marsh on Lake Erie.

6. Background and Rationale

Metzger Marsh is one of the few remnant open coastal marshes along Lake Erie. Most of the coastal marshes unprotected by dikes have lost their vegetation and are essentially part of the lake.

In the early 1900s, a continuous barrier beach isolated the wetland from the lake. During the high water levels in 1929, and again in the late 1950s, the barrier beach was destroyed, permitting high energy waves to destroy the marsh vegetation. Currently, only 12 ha of vegetated marsh exist.

With the destruction of marsh vegetation, and unrestricted access to Lake Erie, the marsh has become unproductive for most species of wetland wildlife, including fish. Water levels fluctuate widely in the marsh and at times provide mudflats for shorebirds or 1.2 – 1.8 m waves. This project, undertaken under the North American Waterfowl Management Plan (NAWMP), seeks to restore emergent wetland vegetation, while permitting open access between the marsh and the lake. This approach has not been successful in the past along Lake Erie, but innovative methods are being implemented to try to maximize coastal wetland values and functions.

7. Regulatory Considerations

a) Completion of a USFWS Environmental Assessment.
b) Filed and obtained a corps of Engineers Section 404 permit.

8. Criteria

These are still being refined because of the lack of data on functions and values of coastal

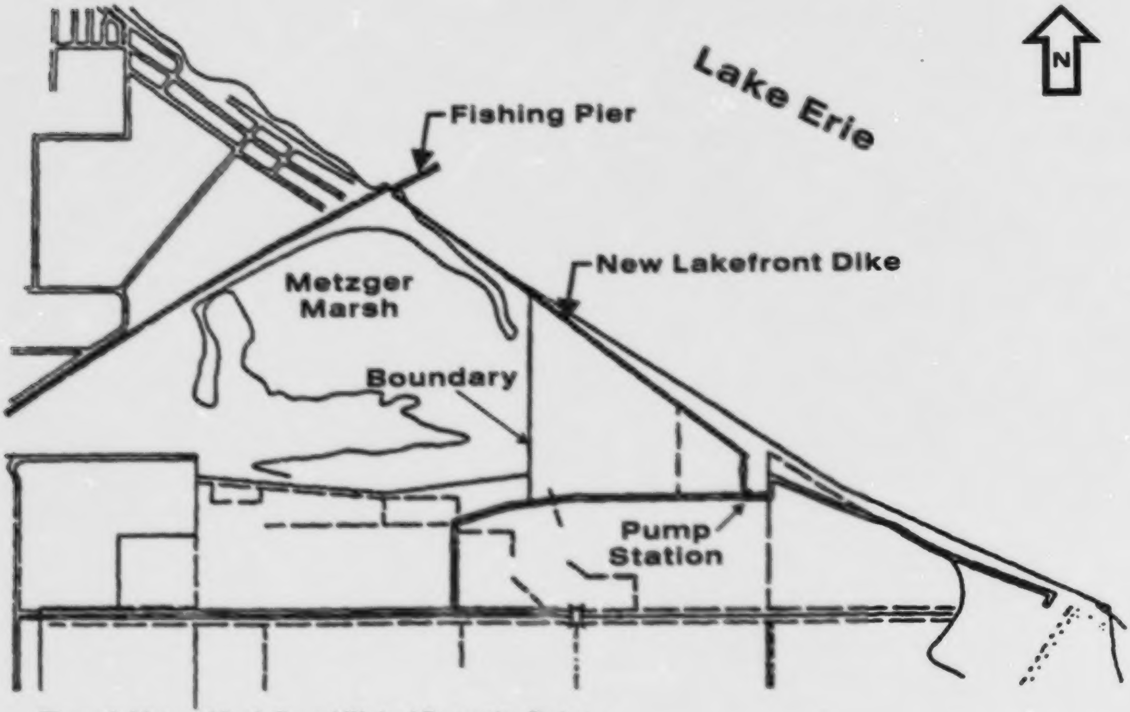

Figure 1. Metzger Marsh Coastal Wetland Restoration Project.

wetlands in Lake Erie. However, the general criteria are to reestablish an emergent coastal marsh with a 40 to 60 % vegetation to open water ratio, with good interspersion. This increase in vegetation should provide substantial wetland wildlife benefits. The project will provide some measure of interchange between the lake and the marsh, along with fish access.

9. Project Design

A 2 341 m lakefront armored dike is being constructed along the original barrier beach contour. A 12 m wide opening, with five 1.5 m control structures, is being constructed in the lakefront dike to provide water interchange and fish passage. A large pump and water control structure will be placed adjacent to the controlled opening to pump and dewater the marsh. The pump and all control structures will provide maximum marsh management capability, from complete closure to complete open access (Figure 1).

10. Implementation

In 1988, the Ohio Division of Wildlife (ODOW) and the USFWS initiated implementation of the NAWMP in Ohio. In the Lake Erie Marshes Focus Area, Metzger Marsh was listed as the number one priority for restoration. In 1992, the ODOW and its 8 partners received a wetland Conservation Act grant to begin restoration. The USFWS also received an appropriation to share in the project, and an Environmental Assessment was completed in 1993 after substantial work and public review. Groundbreaking was held in June of 1994 and dike construction began in October 1994. As of December 1994, half the dike is complete. Full construction of the dike is expected by August 1995, and installation of the pump and water exchange structure is expected in 1996. Two to three years of marsh drawdown will be conducted beginning in 1995 to reestablish vegetation. Some planting of wetland plants may occur. After vegetation has reestablished, the marsh will be open to the lake, and the project monitored for a period of five years.

11. Degree of Environmental Intervention

This restoration project requires a large degree of environmental intervention, because of the intervention that negatively impacted this region and the project site. Approximately 239 498 m^3 of embankment and 118 105 m^3 of rock will be used to build the dike, and significant resources are being used to place and build the pump and water exchange structures. The borrow pit is being constructed as a low level pit with gradual slopes, so as to function as a wetland rather than as a deep sterile pit. Construction will be halted during the February to June bald eagle nesting period because of an adjacent nest. Water levels in the marsh will be controlled for several years to reestablish vegetation, but then will be open to the lake. Water levels may be controlled in the future to reestablish or protect marsh vegetation.

12. Cost

Labour and Materials	$4 720 000
Engineering/Surveys	$378 000
Totals	$5 098 000
Assessment Costs (estimated)	
Survey and Monitoring	$500 000
Total Project Cost	**$5 598 000**(estimated)

13. Biological Assessment

Population and use surveys are being conducted pre-and post-construction for all avian species, mammals, fish, reptiles, amphibians, mussels, macroinvertebrates, and vegetative characteristics. In addition, a seed bank study has been conducted as has a geological review of the project site. Projects are being conducted under the auspices of the ODOW and USFWS, and include partners from the National Biological Survey, University of Toledo, Heidleburg College, The Ohio State University and ODNR-Division of Geological Survey.

14. Measures of Success

Although continually being refined, the principal measure of success will be the establishment and maintenance of emergent marsh vegetation in a ratio of 40-60 % cover to open water after the marsh has been reconnected with the lake. We also plan to use some biological indicators (i.e. increases in bird abundance and diversity, increased fish spawning, etc.). These parameters are very difficult to establish, and will be finalized in early 1995.

Success Rating: 1

15. Key References

None.

Correct citation for this contribution:

Tori, G. 1995. Metzger Marsh coastal wetland restoration project, p. 145–148. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 22

1. Project Title: Urban Stream Stabilization Efforts Which Increase Instream Habitat While Controlling Bank Erosion

2. Contact

Bob Schacht
Illinois Environmental Protection Agency
South First Ave., Suite 600, Maywood, IL 60153 USA
Tel.: (708) 338-7900; FAX: (708) 338-7930

3. Agencies Involved

Illinois Environmental Protection Agency;
U.S. Environmental Protection Agency – Region V;
City of Waukegan;
Waukegan Park District;
Illinois Department of Conservation.

4. Restoration Goal

To demonstrate the effectiveness of stabilizing banks in urban parks along the Waukegan River (Waukegan, Illinois) in order to increase instream habitat and control bank erosion.

5. Project Type

Construction of "lunker structures" (i.e., large wooden boxes with both ends and the streamside open (Figure 1); wooden stringers and rebar are used to anchor the boxes into the bank and streambed) and use of "A-jacks" (i.e., interlocking concrete jacks which help stabilize stream banks during high intensity storms (Figure 2)); dense root systems of willows, dogwood, and grasses will then intertwine throughout the "A-jacks" and provide additional stability.

6. Background and Rationale

The City of Waukegan, State of Illinois and the Waukegan Park District are demonstrating the effectiveness of vegetative stabilization along the Waukegan River in urban parks where high velocity floodwaters have damaged park bridges and city sewer lines. Under provisions of Section 319 of the U.S. Clean Water Act, the Illinois Environmental Protection Agency and U.S. Environmental Protection Agency have funded innovative stream stabilization efforts which increase instream habitat while controlling bank erosion. The urban restoration techniques included construction of "lunker structures" and use of "A-jacks". These structures have been placed at

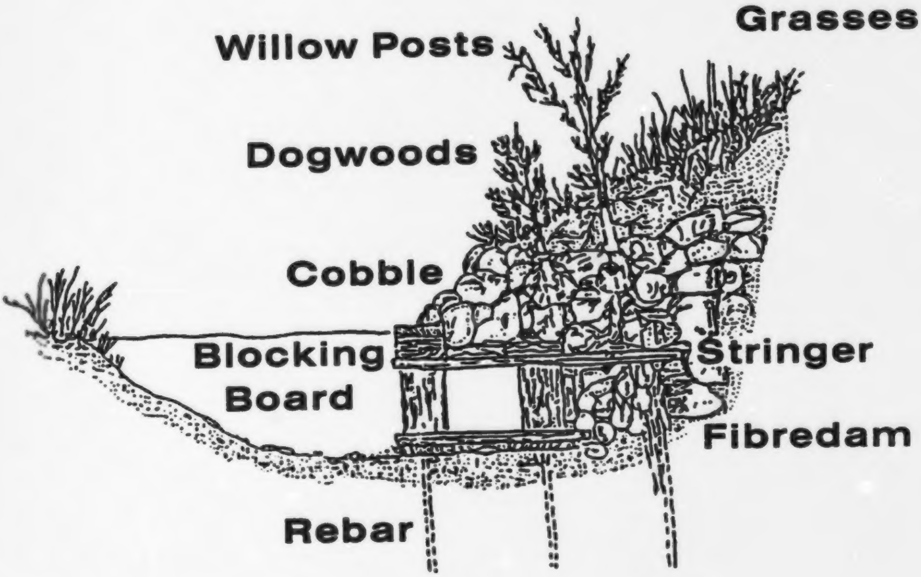
Willow Posts
Grasses
Dogwoods
Cobble
Blocking Board
Stringer
Fibredam
Rebar

Figure 1. Lunker installation design.

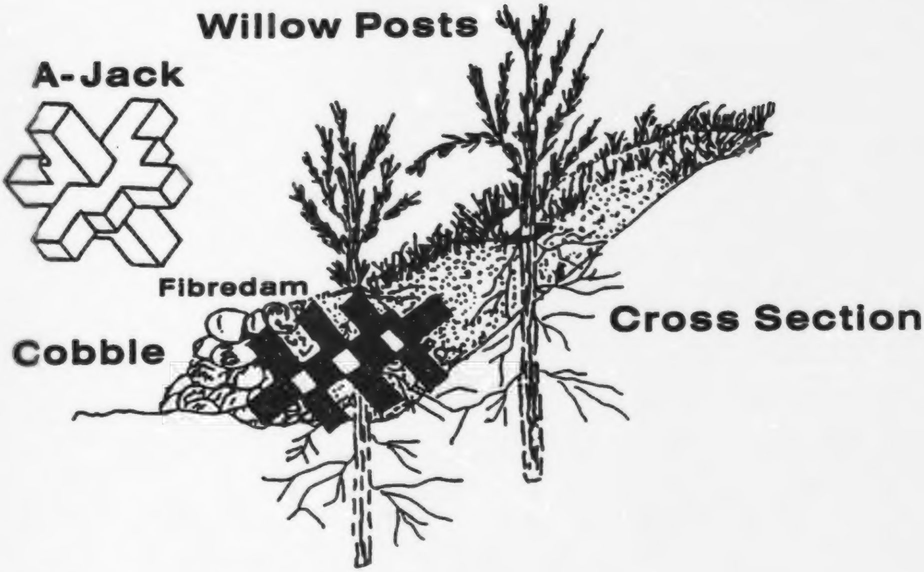
Willow Posts
A-Jack
Fibredam
Cobble
Cross Section

Figure 2. A-Jack design and installation.

three of the most erosive sites and have withstood the severe flooding of 1993 (10.2 cm rain in one hour) without need of repairs.

7. Regulatory Considerations

Urban nonpoint source control requirements under Section 319 of the 1987 U.S. Clean Water Act.

8. Criteria

Considerable loss of gamefish habitat has occurred in most urban areas in the Great Lakes basin. The urban restoration techniques we used were chosen to resist high velocity runoff while increasing instream habitat for gamefish (e.g. bass, channel catfish, and salmon). These techniques provide habitat for gamefish by forming a stable undercut bank through the use of "lunker" structures.

9. Project Design

The project had three main components:

1) design and implement biotechnical stream restoration on three major bank erosion sites;
2) conduct two training workshops for Park District and city personnel, who performed hands-on installation of biotechnical bank protection techniques; and
3) develop stream and riparian maintenance procedures to ensure long-term stream restoration

10. Implementation

The project was undertaken during 1992 and 1993. A backhoe excavated a trench along the base of eroding banks. "Lunker" structures were placed along the entire reach of the eroding banks. Each "lunker" is held in position with nine 1.8 m lengths of 1.6 cm diameter rebar, which is driven into the streambed (see attached diagram). Initially, willow cuttings and small rootballs are placed into the trench behind the "lunker" structure with a geofabric mesh called fibredam. The fibredam reduces soil movement through the "lunker" structure while root systems are developing. Rip-rap of 25.4 cm average diameter and soil are then placed behind and above the "lunker" structure. The A-jacks and "lunker" structure were positioned below the streambed elevation so that any future instability resulting from channel degrading is minimized (see attached diagram). The bank is then sloped over the "lunker" structure and seeded. The seeded grasses are annual rye as the primary matrix and timothy as the secondary matrix. The final seed matrix depends upon the landowner - parks may choose a turf grass; in a nature preserve, the use of wet prairie grasses and flowers may be more appropriate. After initial growth of grasses and willows, additional rooted stock of red osier dogwood were planted near the water's edge. The root masses of the willow and dogwood minimize any soil loss above the "lunker" structure. Both excelsoir blankets and wood chips were utilized as mulch.

11. Degree of Environmental Intervention

Increase ability to withstand high velocity floodwaters in urban environments; minimize streambank erosion and nonpoint source pollutant inputs; enhance gamefish habitat; a hydrological investigation was used to target stream sites.

12. Cost and Resources

Labour and Materials	$164 per meter of bank
Engineering Support	$33 per meter – survey and permit application
On-site Training Program	$1 000 (meeting, video and slides}
Subtotal	$197 per meter of bank
Assessment (estimated):	
Field Crew	10 days/season – data collection and flow measurements
Biologists	20 days/season – data collection and analysis
Other	Chemistry analysis

13. Biological Assessment

Fish surveys and hydrological investigations were used as a basis for project design. The Illinois Environmental Protection Agency and the Illinois Department of Conservation are determining the degree of habitat enhancement and gamefish response in a long-term monitoring effort. Monitoring of the effectiveness of lunker structures in Franklin Creek State Park documented a 300% increase in smallmouth bass fry survival and a 50% increase in large bass residence.

14. Measures of Success

Stabilization of the study reaches has resulted in a reduction in erosion rates along the river and, consequently, a decrease in sediment loads delivered to Lake Michigan. Since erosion along the river has been reduced, further exposure of sanitary sewer lines and the associated damage has diminished. Flow velocities in the river have been decreased sufficiently by the establishment of vegetation to allow sediment to be deposited within the channel.

Success Rating: 4+

15. Key References

Office of Water Quality Management, Illinois State Water Survey. 1994. Waukegan River Restoration in urban Parks. Land and Water. Vol. 38 (5): 33-36.

Correct citation for this contribution:

Schacht, B. 1995. Urban stream stabilization efforts which increase instream habitat while controlling bank erosion, p. 149–153. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 23

1. Project Title: Ruwe Marsh Protection Project – Phase 1

2. Contact

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Lisa Tulen, Project Facilitator
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1023 Richmond St. West, Chatham, Ontario N7M 5J5
P.O. Box 1168 N7M 5L8
Tel. (519) 354-7340; Fax (519) 354-0313

3. Agencies Involved

Great Lakes Cleanup Fund
Landowner and Leasee
Ducks Unlimited
Canadian Wildlife Service
Essex Region Conservation Authority
University of Guelph
Local Girl Guide chapter
Ministry of Natural Resources
U.S. Biological Survey, Dr. Bruce Manny
Dean Construction

4. Restoration Goal

The Ministry of Natural Resources, through the Detroit River Remedial Action Plan, is proposing the repair of an existing finger dyke structure at the Ruwe marsh at the mouth of the Canard River within the Detroit River. This finger dyke is essential in maintaining the integrity of downstream wetlands and dykes protecting the Canard River marsh system. Wind, ice and wave action have caused erosion of the existing clay structure.

5. Project Type

Dyke repair and re-construction; this will involve transportation of armour stone to the site by barge and placement.

6. Background and Rationale

The Ruwe marsh is a privately owned Class 1 marsh located north of the Canard River access in

the Detroit River and is part of a 580.26 hectare wetland complex. This marsh complex consists of two water impoundment cells and an open water marsh mostly within the Detroit River proper. To the north of the wetland cells a long "finger dyke" runs parallel to the wetland dyke. This finger dyke protrudes into the Detroit River approximately 1 125 m and eventually turns in a downstream direction. The finger dyke extends into the Detroit River and effectively trains and re-directs the flow from the Fighting Island Channel around the wetland cells and associated shallow water areas. The recognized significance of the Canard River Marsh ecosystem as staging areas for Canvasback and Redhead ducks, especially during fall migration, results from the finger dyke's diversion of suspended sediments from the marsh. The finger dyke effectively creates a significant amount of calm water area and associated aquatic vegetation. Decreased turbidity allows diverse, abundant aquatic vegetation with high value as food for wildlife. The functional values of the finger dyke sheltering the Ruwe marsh extend throughout the wetland system. The finger dyke and aquatic vegetation of the Ruwe marsh buffer the remainder of the wetlands and dykes from the brunt of riverine forces, shipping channel wash, and ice scour, as well as diverting sediments.
Expected date of implementation pending funding and further approvals: January 1995

7. Regulatory Considerations

All approvals received:

1. Environmental Assessment – Provincal Class EA Planning Procedure;
   Federal Environmental Assessment Review Process, because we were using federal funds (Environment Canada's Great Lakes Cleanup Fund);
2. Fisheries Act – approval from Department of Fisheries and Oceans (December 21, 1994), project deemed mitigable, no compensation necessary;
3. Navigable Waters Protection Act – Approval from Canadian Coast Guard, September 8, 1994;
4. Flood and Fill Regulations — received review comments November 10, 1994, from Essex Region Conservation Authority, requested work permit.

8. Criteria

The key objective of this project is the protection of the existing habitat in this important area of the Detroit River. The existing finger dyke at the north end of the area is under stress from wave action and currents and has eroded considerably. Without this finger dyke, the calm water area to the south of the dyke would be affected by river sediments and current. The finger dyke is essential to maintain the integrity of downstream wetlands and dykes protecting the Canard River marsh system. As the present dyke is composed of clay, further loss of structure and habitat will result if not protected. Side slopes of the dykes should be no greater than 2:1 with 3:1 being preferred. Clean, sediment-free armourstone obtained from the local quarry will be used to repair this dyke.

9. Project Design

Repair and re-construction of the finger dyke will ensure protection of the existing wetland and allow enhancement and maintenance of wetland vegetation through a decrease in current and erosion.

Final engineering designs have been prepared by Jeff Jilek at the London Zone MNR office and are available from the project facilitator.

10. Implementation

Material required for reconstruction of the finger dyke will be from the local Amherst quarry. Construction will be by a private contractor responsible for obtaining material from the quarry, transporting it to the river front, transporting by barge to the site and placement onto the dyke.

11. Degree of Environmental Intervention

This project will require large marine equipment for transportation and placement of material. As this dyke has existed for several years, impacts will be minimal. Material necessary for re-construction will be brought to the site by barge to ensure all existing trees and vegetation will remain intact.

12. Cost

Preliminary project costs for phase 1 of the project have been estimated by Greg Wild of Ducks Unlimited and Dean Construction to cost approximately $300 K. Construction will be tendered to a local marine construction company.

13. Biological Assessment

The Canard River has been chosen as a marsh bird monitoring station for the Area of Concern wide marsh bird monitoring survey program. Reptile and amphibian monitoring will be coordinated by Brian McHattie of the Great Lakes Cleanup Fund. The Ontario MNR has conducted electrofishing surveys of the area in 1992 and a seining program for fish inventory has recently been completed at the wetland in 1994. A specific monitoring program for this project is being developed as a deliverable for the Great Lakes Cleanup Fund proposal.

Recently, Jim Corrigan of the University of Guelph, Biological Control Research Associate, released *Galerucella* sp. beetles as a control for purple loosestrife infestations within the dyked marsh. Future monitoring of purple loosestrife and *Galerucella* sp. colonies will be coordinated by Jim Corrigan and the marsh manager.

14. Measures of Success

Re-construction of this finger dyke structure will protect approximately 366 ha of provincially significant class 1 wetland including the dyked cell and open water marsh with both provincial and national significance. Re-construction will also provide protection to the inner dyke which is

also composed of clay and is eroding due to holes in the outer finger dyke.
Success Rating: 1

15. Key References

Ministry of Natural Resources. 1994. draft version, "Survey of Candidate Sites on the St. Clair and Detroit Rivers for Potential Habitat Rehabilitation/Enhancement".

Correct citation for this contribution:

Hector, D., and Tulen, L. 1995. Ruwe marsh protection project - phase 1, p. 154–157. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 24

1. Project Title: Windsor Salt Riverfront Rehabilitation Project

2. Contact

Don Hector, Project Coordinator
Lisa Tulen, Project Facilitator
Ontario Ministry of Natural Resources (MNR)
1023 Richmond St. West, Chatham, Ontario N7M 5J5
P.O. Box 1168 N7M 5L8
Tel. (519) 354-7340; Fax (519) 354-0313

3. Agencies Involved

Great Lakes Cleanup Fund
Windsor Salt Company
Ministry of Natural Resources
Ducks Unlimited

Other possible funding/partnership groups:
Ontario Ministry of Environment and Energy
United States Army Corps of Engineers
Laidlaw Foundations' Great Lakes Protection Fund
Environmental Partners Fund
Wildlife Habitat Council
Great Lakes Institute of Environmental Research
Environment Canada
Department of Fisheries and Oceans
Canadian Coast Guard
Ministry of Northern Development and Mines
Essex Region Conservation Authority

4. Restoration Goal

Phase 1
Wetland and fish habitat creation.
Phase 2
Rehabilitation of shoreline including construction of spawning channel and ponds for wildlife and fisheries.

5. Project Type

Phase 1
Offshore island construction.
Phase 2
Shoreline alteration.

6. Background and Rationale

1. To protect the mainland shoreline by reducing wave and wind effects and preventing hardening of the mainland shoreline.
2. To provide increased edge and shallow water areas for fish.
3. To create a calm water area to provide benefits for aquatic macrophyte establishment, nursery, spawning and feeding areas for fish, staging and nesting areas for waterfowl, feeding and loafing areas for herons, etc.
4. To create nesting islands for waterfowl and colonial nesting birds such as terns. Islands may provide predator-proof nesting areas for waterfowl.

Phase 1 – An embayment area within the Detroit River to the south of the Windsor Salt docking terminal (approximately 4.4 ha) is experiencing considerable sedimentation problems due to hardened shorelines and groynes downstream of the cove. This area is shallow (less than 1.5 m) and contains a substantial amount of submergent aquatic vegetation. The shoreline area is presently mowed grass and no salt is retained in this area. One outfall is no longer in use following the installation of a cyclone, a purifier which removes $NaCl$ from water; the remaining outfall is releasing levels of brine water ($NaCl$) that are acceptable to Municipal/Industrial Stormwater Abatement (MISA) program standards.
Expected implementation: 1995

Phase 2 – Currently, salt covers most of the shoreline area. The depth of coverage is not known at this time. Some phragmites and low-lying grasses exist along the shoreline. A small mud-flat and narrow creek provide some diversity to the present habitat. A canal intersects the property and provides an inland hydrologic connection. The property north of the canal is separated by a fence from an undeveloped piece of land and is owned by Windsor Salts parent company in Chicago.
Expected implementation: 1996

7. Regulatory Considerations

No approvals at this time:

1. Environmental Assessment- approvals will be necessary for both Provincial Class EA Planning Procedure and Federal Environmental Assessment Review Process, because we were using federal funds (Environment Canada's Great Lakes Cleanup Fund);
2. Fisheries Act- request for review from Department of Fisheries and Oceans July 21, 1994;

3. Navigable Waters Protection Act- request for review from Canadian Coast Guard July 27, 1994;
4. Flood and Fill Regulations-received review comments November 10, 1994 from Essex Region Conservation Authority, support project, will need work permit for construction;
5. Fill Disposal Guidelines- in the event dredge material is used to cap islands, approval from Ministry of the Environment and Energy.

8. Criteria

A series of small islands of less than 0.05 ha in area constructed adjacent and parallel to a drop off within 100 to 200 m from mainland or larger island. The area must be semi-protected from heavy current and heavy ice flows. The windward side of the islands must be protected with sufficient armour and filter material. The lee side of the islands may be left natural with a very gradual slope (4:1) to encourage vegetation to establish. Islands should be constructed approximately 100 m apart or as the fetch dictates.

9. Project Design

Phase 1 – The project involves the creation of a series of offshore islands to protect an embayment area from fetch, ice and wave action. Approximately 4 ha of wetland will be created within the calm water area on the lee side of the island chain. Offshore islands are being designed to increase sedimentation and ensure that flow is acceptable for establishing wetland vegetation and provide resting and possible nesting areas for waterfowl. The calm water areas created by the islands would also increase the area's potential for fish habitat. Spawning shoals made of gabion sized rock would provide enhanced spawning sites for fish species including walleye on the lee side of the island. The islands will be capped and covered with substrate acceptable as nesting areas for Common Terns or planted with wildlife shrubs or prairie grass to provide nesting areas for waterfowl.

Phase 2 – A physical barrier, such as a clay berm, should be constructed between the salt piles and the river. This berm would separate the area targeted for enhancement from the salt piles and provide topographical diversity to the area. Containment of salt piles is a requirement for stormwater abatement under MISA; the company has hired a consultant to write their MISA proposal for early submission. Containment could be achieved through creation of a physical barrier such as a clay berm around the salt piles. This berm would separate the area targeted for enhancement from the salt piles and provide topographical diversity to the area. A barrier channel could be excavated around the island and adjacent to the barrier berm to provide spawning and nursery areas and provide a hydrologic connection to the more inland portions of the site.

The salt contaminated soil should be excavated and disposed of in an appropriate location. The location of the fill would be landscaped so that the elevation of the fill would allow the area to be inundated by river water and therefore create a wetland and island complex where the salt previously existed. The present soil conditions would provide limited growing conditions for vegetation thus limiting any possible rehabilitation efforts. During this process a pond that once existed but has been filled in by salt can be recreated to provide habitat for waterfowl and fish. A creek could also be created to join the canal to the recreated pond. The creek will enhance the diversity of the site.

A series of natural islands could be created adjacent to the shoreline of the site. The islands would provide further shoreline protection from boating traffic and waves as well as providing resting and possible nesting areas for waterfowl.

The U.S. Army Corps of Engineers is presently investigating whether they will be able to provide engineering designs for offshore islands at phase 1. This will involve collecting flow rate and sedimentation data and modelling.

10. Implementation

Phase 1 – Offshore islands will be created by one of two methods. Generic engineering designs are available from the project facilitator. However, at this time, it is unknown whether a borrow pool method will be appropriate due to the possibility of contaminated sediments. The armourstone used in construction will be from the quarry in Amherstburg and is clean material. The islands will be capped and covered with substrate acceptable as nesting areas for common terns or planted with wildlife shrubs or prairie grass to provide nesting areas for waterfowl.

Phase 2 – The salt contaminated soil should be excavated and disposed of in an appropriate location. The location of the fill would be landscaped so that the elevation of the fill would allow the area to be inundated by river water and therefore create a wetland and island complex where the salt previously existed. The present soil conditions would provide limited growing conditions for vegetation thus limiting any possible rehabilitation efforts. During this process a pond that once existed but has been filled in by salt can be recreated to provide waterfowl and fish habitat. A creek could also be created to join the canal to the recreated pond. The creek will enhance the diversity of the site.

A series of natural islands could be created adjacent to the shoreline of the site. The islands would provide further shoreline protection from boating traffic and waves as well as providing resting and possible nesting areas for waterfowl.

A park and recreation area can be created by placing picnic tables in the area, swings and other playground equipment and installing a boardwalk along the creek. Footbridges over the creek as well as the canal would provide access to the property north of the canal. A boardwalk will allow use of the area for nature appreciation and picnics with minimal disturbance of any natural areas created. This aspect of the project will be the responsibility of the company as no direct benefits to the resource exist.

North of the fence separating the Canadian Salt Company from the vacant land to the north of the site, a pond and spawning channel could be created. This area could also be connected to the Canadian Salt Company site via a meandering creek thereby creating a larger site with more diverse habitat potential.

11. Degree of Environmental Intervention

Offshore islands will be constructed by a marine contractor and will likely involve barging and placing material with a back-hoe. Any material used on the offshore islands will be native material including shrubs from native seed or prairie grass from a local source. Appropriate measures will be taken to ensure construction is carried out with the least negative effect including using sediment traps and working during acceptable seasons.

12. Cost

Currently, consultants are being hired to do core sediment analysis with cost unknown at this time. If the Army Corps does engineering for the offshore island design this will be on a 50:50 cost-share basis with actual costs unknown at this time as well. Construction of four offshore islands has been estimated at costing approximately $140 000. The Ontario MNR RAP staff is providing in-kind support through project facilitating including preparation of reports and partnership arrangements.

13. Biological Assessment

The Ontario MNR conducted electrofishing surveys of the embayment area in July. Following island construction a local scuba club will be asked to do some monitoring to observe fish use of habitat. A local naturalist club will be asked to monitor nesting habitat or use by birds. Marsh bird monitoring and amphibian and reptile counts are being coordinated by Brian McHattie for the Detroit River Area of Concern. There is no commercial fish harvest within the Detroit River. Creel surveys were conducted on the Detroit River in 1992.

14. Measures of Success

Future monitoring of the site will aid determining success of the project. Electrofishing will be conducted in the area following island construction and use by wildlife will also be monitored. Establishment of wetland vegetation will also indicate effectiveness of offshore islands.

Success Rating: 1

15. Key References

Ministry of Natural Resources, 1994, draft version, "Survey of Candidate Sites on the St. Clair and Detroit Rivers for Potential Habitat Rehabilitation/ Enhancement".

Correct citation for this contribution:

Hector, D., and Tulen, L. 1995. Windsor salt riverfront rehabilitation project, p. 158–163. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 25

1. Project Title: MacDonald Park Habitat Enhancement Demonstration Project

2. Contact

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3. Agencies Involved

Eastern Habitat Joint Venture
Ducks Unlimited
Great Lakes Cleanup Fund
Ontario Ministry of Natural Resources
St. Clair Parkway Commission
Farmers and Friends Conservation Club

4. Restoration Goal

Demonstration Project – Enhance the manicured landscape to an area that incorporates wildlife and fish rehabilitation.

5. Project Type

Demonstration Project – spawning channel creation, spawning shoal, shoreline sloping, pond excavation.

6. Background and Rationale

MacDonald Park is a day use park owned and operated by the St. Clair Parkway Commission. It is located at Lot A, Concession 3, of Chatham Township. The park consists of a manicured upland with a parking lot and two dredged canals approximately 100 m in length cutting into the park perpendicular to the Chenal Ecarte. The canals are approximately 30 m in width with a mean depth of 2.5 m. A public boat launch and associated parking lots are located on the southern canal.

An agricultural field is located immediately south of the park. This field has a low elevation and is drained by an internal ditch and pump. An artificial dyke separates the Chenal Ecarte from the field. A small strip of wetland vegetation exists immediately on the river side of the dyke as this area is relatively shallow and is conducive to the growth of emergent vegetation. The shoreline of the park is a mix of natural vegetated shore, old wooden breakwall and rip rap shoreline. The agricultural field is privately owned and is currently used for cash crop production.

MacDonald Park provides ample opportunity to enhance fish and wildlife habitat through a variety of rehabilitation techniques while simultaneously furnishing an excellent demonstration project. Expected Date of Implementation: December 1994 - January 1995.

7. Regulatory Considerations

Process on-going (the last of the required approvals anticipated Feb. 24, 1995):

1. Environmental Assessment: Provincial Class EA Planning Procedure; Federal Environmental Assessment Review Process, because we were using federal funds (Environment Canada's Great Lakes Cleanup Fund);
2. Fisheries Act: approval from Department of Fisheries and Oceans, this project should be deemed mitigable, no compensation necessary;
3. Navigable Waters Protection Act: approval from Canadian Cost Guard required and expected by Feb. 24, 1995;
4. Flood and Fill Regulations: SCRCA (St. Clair Region Conservation Authority) presently reviewing (Feb. 24, 1995, deadline), future request for work permit;
5. Ministry of Culture, Tourism and Recreation: archeological concerns have been addressed.

8. Criteria

The canal shorelines will be sculptured to achieve a sloped profile of approximately 3:1. The two adjacent canals will be connected with a meandering spawning channel which would sustain a depth of 0.9 to 1.2 m. The spawning channel will be composed of a sand and gravel combination. The inlet and outlet of this channel should be partially blocked with logs and stumps at both mouths to prevent boat access which may disturb spawning substrate and spawning activity. An excavated pond will have a mean depth of 0.6 to 0.9 m bearing an organic substrate attained through sedimentation. An interspersion of vegetation/open water at a ratio of 1:1 will be maintained in the pond.

The agricultural field south of the park should be incorporated into the plan to provide wetland areas. A dyke should be built along the southern boundary of the field to prevent flooding of the adjacent residential area. The dyke should then be breached along its length in three places to allow the water from Chenal Ecarte to infiltrate the low lying areas of the field and thereby establish a wetland. Another option would be to backflood this area prior to dyke breaching and allowing wetland vegetation to establish under controlled conditions. The dykes would then be breached to allow fish access. The upland areas of this agricultural field would be vegetated in dense nesting cover and shrubs.

9. Project Design

Concept drawings for this project have been completed by the London MNR with final plans and specifications pending.

10. Implementation

Shoreline sloping and spawning channel/pond excavation will be carried out by private contractors adhering to the St. Clair Region Conservation Authority flood and fill regulations. A small expanse of wooden breakwall would have to be removed to allow for shoreline sloping. Work will be completed following MOE guidelines for fill removal. All mitigation techniques are based on and will comply with the Environmental Assessment Act.

11. Degree of Environmental Protection

This project will require the use of heavy machinery such as a backhoe and drag-line. Gravel and rock will be purchased to facilitate the completion of the spawning channel and the spawning shoal. Dyke construction would be handled by private contractors in the event that the agricultural land could be incorporated into the project.

12. Cost

Acquisition of the agricultural field will add substantially to the cost of the project. Initial capital outlay may be reduced by exploring alternative securement methods for this field. The St. Clair Parkway Commission is a government subsidized organization and therefore the park land could remain in their ownership which would eliminate the need for acquisition.
A total project cost is estimated at $50 ,000.

13. Biological Assessment

Amphibian call count monitoring, reptile inventory, electrofishing, and bird counts are intended for what would be a diverse ecosystem. The canals and channel can also be monitored by local scuba divers for fish use.

14. Measures of Success

Success Rating: 1

This project would be given an "assessment incomplete" rating.

15. Key References

Ministry of Natural Resources, 1994, draft version, "Survey of Candidate Sites on the St. Clair and Detroit Rivers for Potential Habitat Rehabilitation/Enhancement".

St. Clair River RAP Ministry of Natural Resources, Rural Lambton Stewardship Network, 1994, draft version, "St. Clair/Sydenham River Regional Habitat Management Plan".

Correct citation for this contribution:

Hector, D., and Colman B. 1995. MacDonald Park habitat enhancement demonstration project. p. 164–167. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 26

1. Project Title: Bear Creek Wetland Creation Project

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3. Agencies Involved

Eastern Habitat Joint Venture
Ducks Unlimited
Nature Conservancy of Canada
Great Lakes Cleanup Fund
Ontario Ministry of Natural Resources
Environment Canada - Canadian Wildlife Service
Rural Lambton Stewardship Network
St. Clair Region Conservation Authroity (SCRCA)

4. Restoration Goal

Wetland creation providing fish and wildlife habitat.

5. Project Type

Wetland creation – dyke and flood farm field.

6. Background and Rationale

The Chenal Ecarte, a tributary channel of the St. Clair River, has historically been an area of ecological significance. There have been serious losses of fish and wildlife habitat primarily due to the accumulative effect of agricultural drainage, filling and urbanization, particularly on the east shores. The Chenal Ecarte is in the Great Lakes/St. Lawrence waterfowl zone ranking within Provincial Priority 1 waterfowl staging habitats.

A series of farm fields is located between the Canadian Wildlife Service property known as the Bear Creek National Wildlife Area and the Mud Creek Hunt Club on lots 16, 17 and 18, Concession 15 and the Broken Front Concession of Dover township, Kent county.

The site consists of approximately 100 ha of farm fields with approximately 10 ha of wetland now used as a hunting club.

Expected Date of Implementation: Fall of 1995

7. Regulatory Considerations

Approvals process to begin this spring (1995):

1. Environmental Assessment: Provincial Class EA Planning Procedure;
   Federal Environmental Assessment Review Process, because we were using federal funds (Environment Canada's Great Lakes Cleanup Fund);
2. Fisheries Act: approval necessary from Department of Fisheries and Oceans, this project should be deemed mitigable;
3. Navigable Waters Protection Act: approval from Canadian Coast Guard required and expected;
4. Flood and Fill Regulations: SCRCA (St. Clair Region Conservation Authority) to review, future request for work permit;
5. Ministry of Culture, Tourism and Recreation: archeological concerns will have to be addressed.

8. Criteria

This project involves the construction of an internal dyke along the southern limit of the specified area. Natural back-flooding will be encouraged in order to create a wetland with hydrological connection to the Chenal Ecarte. Preferred water depth within the wetland will be 30 to 60 cm and water velocity will be minimal with the aid of a water control structure. Habitat within the wetland will be an interspersion of vegetation and open water at a ratio of 50:50. Nesting islands will be constructed within the confines of the newly dyked area using the borrow pool method. Seed plantings will be of a local source and the substrate shall be organic in composition throughout the wetland.

9. Project Design

Dyke construction shall be equivalent to the ARDA (Agricultural and Rural Development Act) dyke specifications. Concept drawings of this project have been completed by an Ontario MNR engineer with the final design to be completed by the partners of the Eastern Habitat Joint Venture this winter (1994).

10. Implementation

Construction of the internal dyke will be carried out by private contractors as will the installation of a water control structure.

11. Degree of Environmental Intervention

Dyke construction will use heavy machinery, such as a backhoe. Project materials will originate exclusively from the site. There are no foreseen detrimental effects to the site.

12. Cost

Exact cost estimates are difficult at this time as they are dependent upon the total area of land that will be acquired. Land acquisition will be the largest cost for this project.

13. Biological Assessment

Amphibian call count monitoring, reptile inventory, electrofishing, and wetland evaluations are intended to monitor the success of the project.

14. Measures of Success

This project would be given an "assessment incomplete" rating.

Success Rating: 1

15. Key References

Ontario Ministry of Natural Resources, 1994, draft version, "Survey of Candidate Sites on the St. Clair and Detroit Rivers for Potential Habitat Rehabilitation/Enhancement".

St. Clair River Remedial Action Plan Ministry of Natural Resources, Rural Lambton Stewardship Network, 1994, draft version, "St. Clair/Sydenham River Regional Habitat Management Plan".

Correct citation for this contribution:

Hector, D., and Colman B. 1995. Bear Creek wetland creation project, p. 168–170. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 27

1. Project Title: Stag Island Habitat Rehabilitation Project

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3. Agencies Involved

Great Lakes Cleanup Fund
Ducks Unlimited
U.S. Army Corps of Engineers
Lambton Industrial Society members

4. Restoration Goal

Phase 1
Wetland creation, enhancement and protection.
Phase 2
Upland rehabilitation.
Fisheries rehabilitation of the shallow waters surrounding the island.

5. Project Type

Phase 1
Alteration of the flow patterns of the wetland and offshore island or breakwall construction to protect the existing wetland.

Phase 2
Enhancement of upland through vegetation plantings (i.e., tall grass prairie and wildlife shrubs).
Fish spawning shoals in the shallows around the island.

6. Background and Rationale

The southern end of Stag Island was used as a dredge disposal site in the late 1960's and is now dry land with minimal coarse vegetation. The interior of the island contains a man-altered Class 3 wetland. Adjacent to the wetland is a possible candidate site for an "Old Growth Oak Forest " designation.

Sand bed-load moving with the river current has covered the river bottom off the northern point of the island, along the western shore extending south of the island several hundred metres. These sand shoals are considerable in width and at times extend 200 m west of the island. Water depths in the shoal areas range up to but seldom exceed 2 m. In some areas of the shoal, submergent aquatic vegetation such as Canadian waterweed has established. These areas of aquatic vegetation are mainly located in the calm backwaters and are not generally found within high flow areas.

The Class 3 wetland located towards the middle of the western shore is a series of dredge created spits and shallow water canals. Portions of the spits are inundated by water and afford good quality transitional wetland. The remainder of the spits offer higher upland that may be managed for waterfowl production. The entire wetland system has very shallow water with minimal boat access.

The southern portion of the island is owned by the Crown and is operated as the Stag Island Provincial Hunting Area. This area built up because of the now abandoned practice of dredge disposal from the St. Clair River which took place in the late 1960's. The southern tip is higher in elevation than the adjacent centre island wetland or the river water level. The shoreline is extremely erodible with a fairly steep bluff approximately 2–3 m in height. This portion of the island is largely composed of clay and sand and supports only coarse vegetation and a few small shrubs.

Stag Island presents an excellent opportunity to rehabilitate habitat in the upper reaches of the St. Clair River. This island shoal historically supported a large amount of wetland vegetation, particularly on the southern tip of the island. The objectives of the rehabilitation plan for Stag Island are; Phase (1) to protect and enhance the existing wetland for fish and wildlife production; and Phase (2) to re-create as much wetland as possible by creating calm water areas within the shallow waters of the island.

7. Regulatory Considerations

No approvals sought to date.

1. Environmental Assessment: Provincial Class EA Planning Procedure
   Federal Environmental Assessment Review Process, because we were using federal funds (Environment Canada's Great Lakes Cleanup Fund);
2. Fisheries Act: approval necessary from Department of Fisheries and Oceans, this project should be deemed mitigable;
3. Navigable Waters Protection Act: approval from Canadian Coast Guard required;
4. Flood and Fill Regulations: SCRCA (St. Clair Region Conservation Authority) to review, future request for work permit;
5. Ministry of Culture, Tourism and Recreation: archeological concerns will have to be addressed.

8. Criteria

Not available.

9. Project Design

Phase 1

Technique
Increase edge area and water area in the canal complex by breaking the land ridges into a series of islands through mechanical excavation and deposition of spoils onto the new islands. Areas of existing land ridges which currently demonstrate wetland values would be left unaltered.
Benefit
Islands would increase edge effect and thereby add diversity in the canal complex. Water area would increase by approximately 25%. The newly created islands would provide waterfowl nesting areas and cover, as well as nesting and feeding areas for other birds.

Technique
Placement of logs, stumps and gabion rock shoals in the canals.
Benefit
Structure would add diversity to the existing open canals. Cover for fish would be provided as well as enhanced spawning areas. Exposed logs and stumps would act as loafing areas for waterfowl and turtles.

Technique
Placement of waterfowl nesting structures (i.e., nesting boxes and platforms.)
Benefit
Provide the nesting structures necessary to increase waterfowl production on this site.

Phase 2

Technique
Excavation of a pond system or a series of canals within hunting area.
Benefit
Waterfowl production, feeding and staging areas would be created.

Technique
Add topsoil to remainder of the area and plant with native tall grass prairie, shrubs and herbaceous plants.
Benefit
Provides cover, nesting and food production areas for small mammals, birds and herptiles.

Technique

Create walleye spawning shoals in the shallow shoal area south of the island's southern tip using gabion stone unloaded from a dump scow. An exposed rock berm, constructed convex to the current, should be constructed on the upstream side of the shoal to deflect bed-load around the spawning shoal.

Benefit

The shoal is presently devoid of structure and comprised of sand and small pebbles. Gabion stone shoals would provide walleye spawning areas.

Technique

Construction of an offshore breakwater in 2 m of water, west of the wetland area.

Benefit

A breakwater will reduce the impact of wakes and wind produced waves on shoreline structure and vegetation. A calm water area would be created, facilitating the accumulation of organic material and nutrients which in turn would promote the growth of aquatic vegetation. A breakwater would also provide physical structure for a fisheries food production area.

Technique

Placement of logs, stumps and gabion stone shoals in the calm water area east of the breakwater.

Benefit

Provide cover and spawning substrate for a variety of fish species.

10. Implementation

Material Selection:

1) Native seed sources only.
2) On site materials for construction with the exception of armourstone which will be brought in by barge from Amherstburg Quarry.

Models Used: HEC-2 model for the river to determine impact of islands/breakwaters and best design determination.

Engineers Drawings: Completed by the London Zone Office of the MNR and are available from the Project Facilitator.

Problems or Catches in Implementation: The Inland Boundary Waters Treaty of 1909 now being enforced.

11. Degree of Environmental Intervention

Excavation work will involve the use of backhoe and/or dragline. A barge will be used to deliver armourstone to the site. As the area slated for major construction is relatively sterile with respect to fish and wildlife occupation, environmental impact should be minimal. All excavated materials will be disposed of on site.

12. Cost

Phase 1 cost:	$530 000
Phase 2 cost:	$460 000

13. Biological Assessment

Monitoring:
A number of different techniques will be used to monitor the progress of the rehabilitation. These include the following:

1) Electrofishing (by boat and backpack) and seine netting to monitor changes in fish populations and diversity.
2) Monitoring nesting boxes to determine hatch success.
3) Monitoring or counting of amphibian calls in the spring of the year to determine diversity and population size estimates.
4) Plant inventories may be performed to determine the effects on the plant communities.
5) A re-evaluation of the wetland may be necessary to up grade the wetlands classification.

14. Measures of Success

Indicators include:

- habitat area increase
- species diversity increase
- population size increase.

Success Rating: 1 – assessment incomplete

15. Key References

Ontario Ministry of Natural Resources, 1994 draft version of "Survey of Candidate Sites on the St. Clair and Detroit Rivers for Potential Habitat Rehabilitation/Enhancement".

OMNR/St. Clair River RAP/Rural Lambton Stewardship Network, 1994, "St. Clair/Sydenham River Regional Habitat Management Plan"

Correct citation for this contribution:

Hector, D., and Colman, B. 1995. Stag Island rehabilitation project, p. 171–175. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. 1.

Project 28

1. Project Title: D'Arcy McKeough Floodway Habitat Enhancement Project

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3. Agencies Involved

Ducks Unlimited
Ontario Ministry of Natural Resources (MNR)
Rural Lambton Stewardship Network
St. Clair Region Conservation Authority (SCRCA)
Great Lakes Cleanup Fund

4. Restoration Goal

Enhance the existing vacant land within the floodway into wetland thereby providing aquatic and semi-aquatic habitat for a variety of birds, mammals, reptile, and amphibian species. Vacant berms surrounding the floodway would provide nesting, shelter, and feeding opportunities for a variety of songbirds and small mammals.

5. Project Type

Wetland creation as well as "prairie pothole" ponds and wildlife habitat enhancement.

6. Background and Rationale

A by-pass floodway was constructed in the mid 1970's connecting the north branch of the Sydenham River to the St. Clair River. The floodway runs in an east to west direction just south of Wilkesport in Sombra Township to the St. Clair River with the outlet being immediately east of Fawn Island. The floodway is used to prevent flooding of the Town of Wallaceburg. When flood waters rise in the two rivers, the Wilkesport dam is closed and re-directs the flood waters down the floodway to the St. Clair River. During the non-flood periods, which is almost all year, the floodway is dry except for a small channel containing run-off from the floodway itself.

The floodway bottom is approximately 100 m in width with a uniform, flat profile. The sides of the floodway are at a 3:1 slope. At the top of the slopes are berms which were created from the dredge material from the floodway itself. The slopes are approximately 10 m in vertical height. A concrete head-wall, 1 m in height, is 350 m east of the County Road 33 bridge at the outlet of the floodway. A 15 cm culvert allows run-off water to drain through the head-wall. The bottom of the floodway is currently planted in hay which at one time was harvested by local cattle farmers. The hay, however, is of poor quality and is difficult to harvest due to access problems.

Expected Date of Implementation: 1995/1996

7. Regulatory Considerations

Approvals on-going:

1. Environmental Assessment: Provincial Class EA Planning Procedure
   Federal Environmental Assessment Review Process, because we were using federal funds (Environment Canada's Great Lakes Cleanup Fund);
2. Flood and Fill Regulations: SCRCA presently reviewing (Feb. 24, 1995 deadline), future request for work permit.

8. Criteria

The primary objective is to develop a wetland area within the floodway with a uniform water depth of 30 to 60 cm. Ideally this wet area will have an interspersion of 50% vegetation and 50% open water. Water velocity throughout the wetland should be minimal. Supplemental macrophyte plantings will be of native shrub seed and grass seed. The grasses will be planted in a succession nature, planting shorter species along the wetland fringe and gradually increasing the height of the species with distance from the wetland. A series of "Prairie pothole" ponds will be created within the floodway with a maximum depth of 60 to 90 cm. The existing clay substrate within the floodway will be maintained for the pond creation.

9. Project Design

The project design will be subject to review by Ontario MNR engineers for hydraulic concerns.

10. Implementation

The excavation of ponds, as well as the installation of a water control structure, within the floodway will be handled by a private contractor and will conform to Ontario MNR guidelines. Supplemental native aquatic plant seed would be acquired from local nurseries in the event that natural aquatic regeneration of the floodway was unsuccessful. A local native seed source will accommodate the revegetation of floodway slopes.

11. Degree of Environmental Intervention

Excavation of "prairie pothole" ponds within the floodway will involve the use of a backhoe. As the existing project area is relatively sterile with respect to fish and wildlife species, environmental impact should be minimal. All seed sources will be native, and excavated or piled material will all originate from the site.

12. Cost

Costs are minimal in the design and construction of the valve and inlet structure. Vegetation and shrub planting could be incorporated into existing SCRCA and Ontario MNR tree planting programs. The only substantial cost, pending estimates from local contractors, would be the construction of the ponds.

13. Biological Assessment

Amphibian call count monitoring, nesting structure monitoring, and wetland evaluations are optimal activities to realize the success of the newly created wetland ecosystem.

14. Measures of Success

Biological assessment of the rehabilitated portion of the floodway should provide indicators of success.

Success Rating: 1

15. Key References

Ministry of Natural Resources, 1994, draft version, "Survey of Candidate Sites on the St. Clair and Detroit Rivers for Potential Habitat Rehabilitation/Enhancement".

St. Clair River RAP Ministry of Natural Resources, Rural Lambton Stewardship Network, 1994, draft version, "St. Clair/Sydenham River Regional Habitat Management Plan".

Correct citation for this contribution:

Hector, D., and Colman, B. 1995. Darcy McKeough floodway habitat enchancement project, p. 176–178. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 29

1. Project Title: Aquatic Macrophyte Establishment in McKellar River Embayments at Thunder Bay, Ontario

2. Contact

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3. Agencies Involved

Department of Fisheries and Oceans, Sault Ste. Marie, Ont.
Lake Superior Remedial Action Program, Thunder Bay, Ont.
Lakehead University, Thunder Bay, Ont.

4. Restoration Goal

Increase wetland habitat for waterfowl, fish and amphibians.

5. Project Type

Comparison of artificial and natural regeneration of plant species in newly created embayments on the McKellar River.

6. Background and Rationale

Shoreline wetlands in Lake Superior are important as land-water interfaces and attract many vertebrates and invertebrates through the provision of both food and shelter afforded by an abundance of aquatic macrophyte growth. However, in the Canadian portion of Lake Superior there are less than 1200 ha of wetlands, and major areas of this habitat have been greatly reduced near industrialized areas. In order to improve the situation, new wetlands are being established under Remedial Action Plans. These new wetlands are expected to enhance fisheries production and provide habitat for waterfowl and amphibians.

The speed and extent by which aquatic macrophytes colonize newly created wetlands is not known in Lake Superior. Nor is it known whether colonizing species will be desirable from both a production and cover point of view. Elsewhere, the approach has often been to artificially establish aquatic macrophytes deemed to be desirable for the end target (fish, waterfowl, etc.). In this study, natural versus artificial macrophyte colonization is being examined in two nearly identical (in size, depth, substrate, wind fetch), newly constructed embayments on the McKellar River.

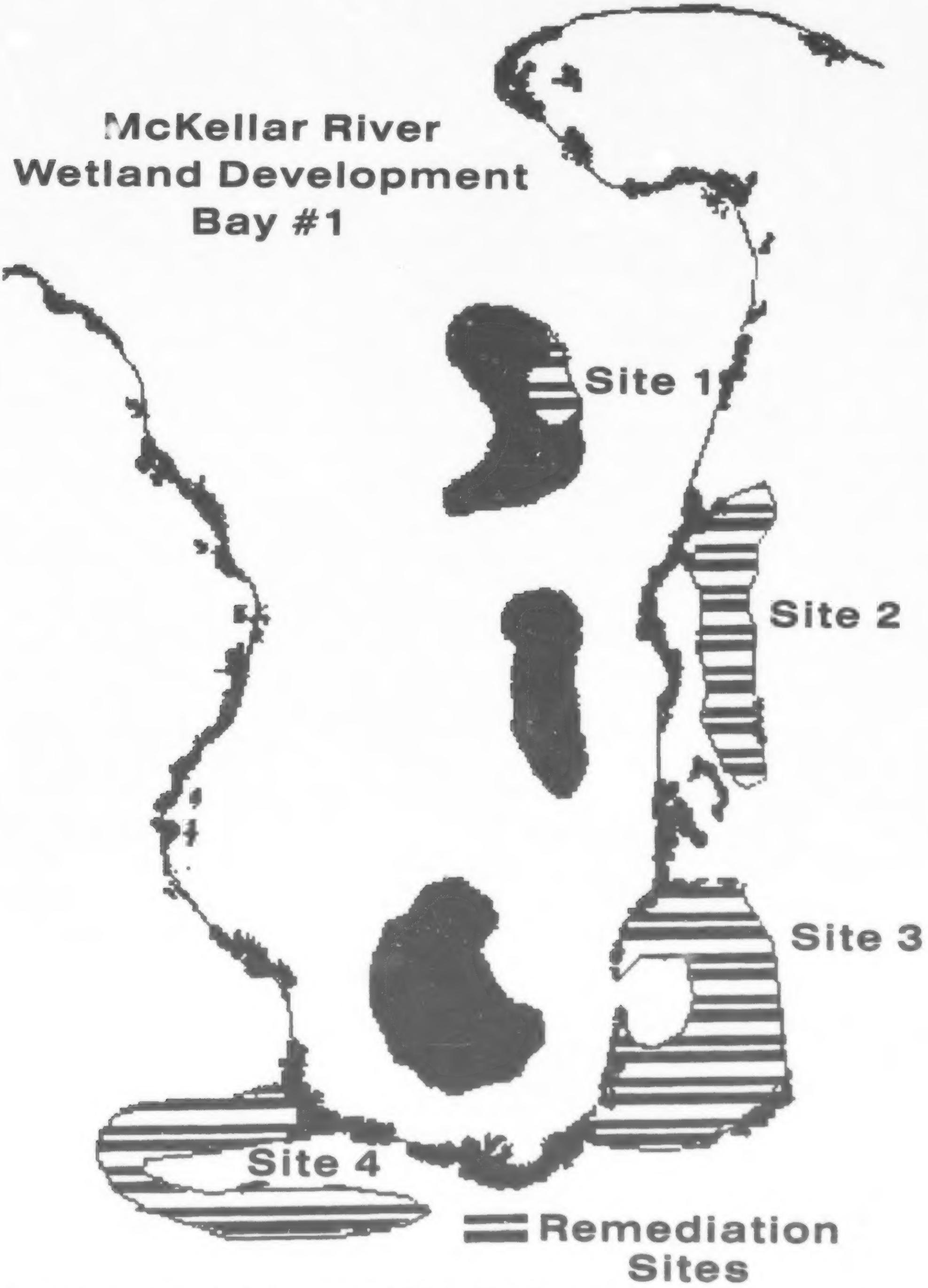
McKellar River
Wetland Development
Bay #1
Site 1
Site 2
Site 3
Site 4
Remediation
Sites

Figure 1. Locations of planting Sites 1 – 4 in the McKellar River Embayment #1.

7. Regulatory Considerations

There are no regulations governing the introduction of native aquatic plants.

8. Criteria

The plant establishment zone in wetlands is limited by depth and sediment type (and inter-and intraspecific plant competition in natural situations). Aquatic plants differ in their response to these two variables.

9. Project Design

In the embayment to be artificially colonized, plant species were matched to their known depth tolerances. A total area of 0.19 ha was to be planted. All plant species used were native to the Kaministiquia Valley as per the National Museum of Canada's Syllogeus 63 "Flora of the North Shore of Lake Superior (Vascular plants of the Ontario Portion of the Lake Superior Drainage Basin)" by J.H. Soper, C.E. Garton and D.R. Given. The planting sites (Figure 1) were designed to provide habitat for fish, waterfowl, and amphibians. Site 1 was most affected by wave action from wind and passing boats and species were used that were tolerant of these conditions. Site 2 and Site 3 were easily seen from the embayment lookout and so species were included that should attract waterfowl and other marsh birds. As well as being visually attractive, the water lilies in Site 3 should be important for amphibians. Site 4 was most visible from the road leading into the embayments and so taller species were selected to give privacy to colonizing bird species. Planting schematics are available by contacting the author.

10. Implementation

No physical manipulation of the environment was possible. In some cases this resulted in plants being placed in locations which were not ideal in terms of slope and soil type.

The proposed areal coverage by species, recommended planting densities, and total plants to be used per species were as below:

Species	Aerial coverage (m^2)	Recommended Planting Density	Total Plants Required
Eleocharis smallii	170	30 cm centres	1830
Scirpus lacustris	276	60 cm centres	1487
Sagittaria latifolia	143	48 cm centres	963
Polygonum amphibium	261	30 cm centres	2814
Calla palustris	18	24 cm centres	247
Glyceria canadensis	17	15 cm centres	360

Zizania aquatica	77	30 cm centres	832
Iris versicolor	42	15 cm centres	904
Phragmites communis	51	30 cm centres	546
Caltha palustris	45	60 cm centres	241
Nuphar variegatum	36	5 per 7.5 m centres	78
Nymphaea odorata	144	5 per 7.5 m centres	310
Juncus effusus	79	30 cm centres	852
Potamogeton pectinatus	131	30 cm centres	1415
Vallisneria americana	240	30 cm centres	2581
Sparganium eurycarpum	113	30 cm centres	1215
Total	1844		15034

All species were collected within the drainage basin and transplanted or nursery grown in large holding tanks at Lakehead University and then transplanted. A key part of this operation was locating large enough stands of the various species prior to actually collecting them.

Planting was done by digging the roots or rhizomes into the bottom substrate. The waterlily rhizomes were first wrapped in cheesecloth, weighted with rocks, and them planted. Wetsuits were necessary for this operation due to the cold water temperature.

Best results in terms of recovery from planting shock were obtained when the plants were transplanted within 24 h of being collected. Plants were held in water in large coolers until they could be transplanted.

Difficulty was experienced in collecting or nursery growing sufficient quantities of *Vallisneria* for a single season project. Mortality was quite high for nursery rearing *Sparganium*. In order to transport large numbers of this species from the collection site in the storage coolers, the stems were cut off to a height of approximately 15 cm. If these stems were then totally submerged in the nursery tanks, the plants died.

Large numbers of Canada Geese invaded the wetland soon after planting and caused considerable damage. Further damage was virtually eliminated by erecting snow fence around the planted sites and tying string with coloured flagging tape attached between the fence borders.

11. Degree of Environmental Intervention

The planting of selected species at the embayment will likely affect the natural colonization of species in the area. The immediate area, however, is highly disturbed and the species are from the same drainage basin where no disturbance has occurred.

The removal of plant species from natural wetlands to colonize this created wetland is also of environmental concern. Care was taken to select large enough stands of the plants such that the source population should easily recover. It is noteworthy that many of the species were collected on private land and it is likely that collection locations for these species could be found entirely on private land in the Thunder Bay area. This provides a feasible alternative to nursery stock.

12. Cost

Plants (locating, collecting, storage)	$10 000
Nursery Expenses and Care	$3 500
Nursery Planting and Removal	$ 5 000
Site Planting	$3 000
Total	**$21 500**
Lakehead University Services	$ 4 300
Grand Total	**$25 800**

13. Biological Assessment

A species was defined as successfully transplanted if new growth appeared. The introduced plants were monitored at biweekly intervals for this factor after transplanting.

The two embayments were also compared at the end of the first growing season for percent cover of all species present. This monitoring should continue in future years.

14. Measures of Success

The wetland plantings will be considered successful if transplanted species can regenerate in future years. Initial results for 1994 suggest that the transplanted embayment has considerable more vegetation coverage than the non-transplanted embayment.

Success Rating: 4 – but will require monitoring in future years.

15. Key References

Odum, H.T. 1989. Ecological engineering and self-organization. *In* W.J. Mitsh and S.E. Jorgensen [*editors*]. Ecological Engineering. Wiley, New York, NY.

Correct citation for this contribution:

Lee, P.F. 1995. Aquatic macrophyte establishment in McKellar River embayments at Thunder Bay, Ontario, p. 179–183. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 30

1. Project Title: Lake Orion Water Quality – Habitat Improvement Project

2. Contact

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3. Agencies Involved

Michigan Department of Natural Resources
Trout Unlimited
Michigan Wildlife Habitat Foundation

4. Restoration Goal

To maintain downstream water temperatures of less than 21°C to sustain a year-round brown trout (*Salmo trutta*) population.

5. Project Type

Modification of flow; use of a control structure to discharge bottom-draw flows of cool water.

6. Background and Rationale

Paint Creek is one of the few trout steams in southeast Michigan. Wild and stocked brown trout provide angling opportunities in the cooler portion of Paint Creek. Each summer brown trout up to 51 cm in length are reported caught. The rationale was that mixing cold, deep lake water with warm surface dam discharges at Lake Orion would improve and expand brown trout habitat in the dam-impacted reach of Paint Creek below Lake Orion.

7. Regulatory Considerations

Inland Lakes and Streams Act (Act 346); Michigan Department of Transportation permit to drill under highway; needed to acquire easements from several property owners and the City of Lake Orion; needed regulatory approval to alter water control structure and for placement of the pipe.

8. Criteria

Improve and sustain desired brown trout water temperatures and dissolved oxygen concentrations (primary criterion was maintaining water temperatures below 21°C in Paint Creek).

9. Project Design

The project was designed to tap cold water from the lower reaches of Lake Orion and blend this water with lake surface water coming over the dam to maintain downstream water temperatures below 21°C.

10. Implementation

In 1991, a 46 cm diameter tube, 226 m long, was placed on the bottom of Lake Orion, tapping cold water from 19 m deep. A control structure discharges the bottom-draw flows through another 69 m of pipe under a five lane highway and into Paint Creek at the base of the Lake Orion dam. Summertime bottom draw temperatures (approximately 10-12°C) are blended with lake surface dam discharge temperatures to maintain a downstream temperature below 21°C. Brown trout were planted in 1992 immediately below the dam and thrived throughout the summer. Some 5–7 km of the stream were therefore improved for year round trout survival.

11. Degree of Environmental Intervention

No impacts from drilling; minimal disruption by laying tube on bottom of lake.

12. Cost

Labour, Materials, and Engineering Support	$62 827
Assessment Costs (estimated)	< $5 000
Total project cost	approximately **$67 000**

13. Biological Assessment

Physical, chemical, and biological assessments were performed. A 1992 post-project survey concluded:

- water temperatures in Upper Paint Creek were cooled, providing over 5 km of new trout stream habitat and providing more stable water temperatures;

- stocked brown trout survived the summer in Upper Paint Creek as a result of cooler water temperatures;
- more stable water temperatures have also helped protect the brown trout population through winter; and
- cool and cold water aquatic insects (e.g., blackflies, stoneflies, caddisflies) colonized Upper Paint Creek.

A follow-up survey in 1993 concluded that routine maintenance and control was required to achieve the optimum mix of bottom-draw waters and dam discharge waters in order to maintain downstream water temperatures below 21°C and sustain the brown trout population.

14. Measures of Success

The project was very successful and met all expectations.

Success Rating: 4 – long-term monitoring underway

15. Key References

Spitler, R.J., and Thomas, M. 1992. Lake Orion - Paint Creek Bottom Draw Summary. Michigan Department of Natural Resources, Fisheries Division, Livonia, MI, 7p.

Spitler, R.J., and Thomas, M. 1992. Lake Orion - Paint Creek Water Quality Improvement Project, Progress Report. Michigan Department of Natural Resources, Fisheries Division, Livonia, MI, 5pp.

Correct citation for this contribution:

Spitler, R.J. 1995. Lake Orion water quality-habitat improvement project, p. 184–186. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 31

1. Project Title: Belle Isle Canal Rehabilitation

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3. Agencies Involved

City of Detroit, Recreation Department
Michigan Department of Natural Resources (DNR): Fisheries Division, Land and Water Management Division, and Recreation Division
U.S. Department of Interior, National Biological Survey.

4. Restoration Goal

Restore the lakes and canals on Belle Isle to:

- Improve aquatic habitat
- Reintroduce sport fishing and recreational canoeing
- Create positive water flow
- Improve island water circulation
- Improve visual aesthetics
- Reduce maintenance burden

5. Project Type

The project is a 13-stage Rehabilitation Program which includes hydraulic improvements, treatment of exotic vegetation, point and non-point source discharge modification, and wetland and deep water habitat creation.

6. Background and Rationale

Belle Isle is a 398 ha island park located in the Detroit River within close proximity to the downtown district of the City of Detroit. The island has been one of the most revered and heavily used parks in the City. The lakes and canals on the island have traditionally been a prime focus of recreational activities and provide valuable wildlife and fisheries habitat as well as aesthetic value. The lakes and canals had become seriously degraded resulting in deterioration of aquatic habitat and elimination of recreational opportunities. The City of Detroit initiated a detailed investigation of the lakes and canals which culminated in a Rehabilitation Program.

The rehabilitation of the lakes and canal system requires a long-term management strategy integrating a multidisciplinary and comprehensive approach, incorporating science and technology from engineering, biology, hydrology, aquatic chemistry and land use. The proposed Rehabilitation Program includes 13 stages to be implemented over several years.

7. Regulatory Considerations

Several regulatory actions were required to initiate this project as follows:
- Completion of an extensive study of existing hydrological, ecological and land use conditions on the island;
- Completion of an Army Corps of Engineers Section 404/Michigan DNR P.A. 203 Permit Application for dredge and fill activities within the waterways of the State;
- Completion of a Michigan DNR Permit Application to apply herbicide for the removal of invasive, exotic plant species.

8. Criteria

The following criteria have been established by the Rehabilitation Program:
- Installation and relocation of new pumps to deliver 37,850 liters/min;
- Removal of invasive, exotic vegetation and introduction of desirable native wetland vegetation;
- Improve circulation within the system by reducing flushing time to 5 days;
- Remove point source discharges;
- Create approximately 1.2 ha of deep water habitat;
- Create emergent wetland habitat adjacent to the deep water habitat;
- Provide a direct connection to the Detroit River to create additional spawning, nursery and cover habitat for the river fishery;
- Implement a fish stocking program within the isolated lakes and canals in cooperation with the MDNR Fishery Division.

9. Project Design

The Rehabilitation Program will restore historical recreational uses of the lakes and canals. In addition, the program will provide new aquatic habitat which will support a limited fishery on the island and add habitat diversity. The program will duplicate the historical depth and width of the canals and lakes and add deep water habitat in two locations. Design flow will be achieved by installation and relocation of new pumps and dredging of the canals.

10. Implementation

The Rehabilitation Program is designed to be implemented over several years. Vegetation treatment began in 1992 and continued through 1994. New pumps have been purchased and are expected to be installed in the spring of 1995. Dredging construction documents have been completed and dredging will occur in the winter of 1995. The remaining activities are scheduled to be implemented over the next 2 years.

11. Degree of Environmental Intervention

No primary environmental perturbation will occur as a result of the dredging activities. Dredging activities will include a limited clean-out and deepening of the canals. The dredged material will be used to rebuild the eroded banks. Two 0.6 ha deep water habitat areas will also be created resulting in a total of approximately 29 054 m^3 of dredge material. Some of this material will be used to stabilize eroded banks; other material will be used for wetland creation.

Environmental impacts from dredging will be minimized by drawdown of the system prior to dredging and conducting dredging in the winter. These precautions will minimize suspension of sediments and discharge to downstream locations.

12. Cost

The estimated total cost of the 13-stage Rehabilitation Program is $1.2 million.

13. Biological Assessment

The project was initiated with a thorough assessment of the biological resources within the lakes and canals. The assessment identified the causes and sources of the degraded conditions within the waterways and resulted in the identification of the Rehabilitation Program to correct problems and restore aquatic habitat. Since this program has just begun to be implemented, no evaluation of the success of the program is available.

However, following implementation of the program an assessment of the aquatic resources will be conducted to determine if the program was successful. Indicators of success would include aquatic habitat diversity, viable fishery habitat, survival of diverse aquatic organisms, establishment of diverse native aquatic vegetation, and restored recreational usage of the lakes and canals.

14. Measures of Success

Program has just begun to be implemented.

Success Rating: 1

15. Key References

Johnson Johnson & Roy Inc. 1993. Belle Isle Canal Rehabilitation.

Correct citation for this contribution:

Denison, D.L., Riseng, C.M., and Rausch, L.P. 1995. Belle Isle canal rehabilitation, p. 187–190. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 32

1. Project Title: Lake Erie Biological Criteria and Habitat Evaluation Project

2. Contact

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Chuck McNight (macroinvertebrate communities)
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3. Agencies Involved

Ohio Environmental Protection Agency
U.S. Environmental Protection Agency (USEPA), Region 5, Water Division
Lake Erie Protection Fund
State of Ohio

4. Restoration Goal

The goal of this project is to monitor fish and benthic macroinvertebrate communities and evaluate the ecological status and functions of the numerous habitat types (both natural and human altered) that are found in the Lake Erie area of Ohio. Further, it is intended that the information obtained will be used in the evaluation of proposed habitat modifications to determine potential impacts and possible design changes that could make the project environmentally compatible in the most cost-effective manner. Data from this project is being used in the Ohio EPA 401 Water Quality Certification Program and to support other water quality management programs and objectives.

5. Project Type

Biological monitoring of fish and benthic macroinvertebrate communities.

6. Background and Rationale

The Ohio EPA has long issued 401 permits for dredge and fill activities in the Lake Erie area. Part of the Ohio Water Quality Standards (covered in the 401 permit) are biological measures of environmental condition and potential. Rigorous development of biological standards (criteria) have not yet been completed for the Lake Erie area. This project is an effort to develop scientifically defensible standards that, in part, can be used to assess impacts from habitat modification activities and generate recommendations for environmentally sustainable alternatives.

7. Regulatory Considerations

Collecting permits must be obtained from the Ohio Department of Natural Resources for all work and the U.S. Department of Interior for any work conducted on federal lands (i.e., refuges).

8. Criteria

1) Development of a cost-effective biological monitoring technique that yields consistent and reproducible results through standardized methods.
2) Development of criteria (expectations) that can be used to assess the degree of attainment (how closely do biological communities approximate those found in areas of least disturbance) in the variety of habitat types found in the Lake Erie nearshore area.
3) A biological assessment of the habitat types found in the Lake Erie nearshore areas that allows the discrimination of high and low quality habitat types.

9. Project Design

Phase 1 – Evaluate practicality and effectiveness of numerous sampling methodologies for both fish and benthic macroinvertebrate communities and select the methods to be standardized. Conduct first year sampling in estuary streams and proximal lake shore areas (1993).

Phase 2 – Develop and evaluate alternative metrics to be used in an Index of Biotic Integrity (following the protocols stipulated by Karr 1981 and Fausch et al. 1984) modified for application to the Lake Erie area and derive numerical biological criteria based on the biological community performance observed at least disturbed reference sites. Conduct second and third year sampling in estuary areas, proximal lake shore areas and Lake Erie islands (1994 and 1995).

Phase 3 – Conduct lake shore sampling in areas between major tributaries, evaluate all habitat types, analyze lake shore data base and compile report on conditions (1996 and 1997).

10. Implementation

This project was initiated in 1993 and should be completed by the summer of 1997. Ohio EPA first began biological assessments in the Lake Erie area in 1982 and has accumulated data in each succeeding year. This historical database will be used in the project. Long range plans include biological monitoring in the Lake Erie area as an ongoing activity for the Ohio EPA. Benthic macroinvertebrate monitoring is primarily conducted using Hester-Dendy artificial substrate samplers (Figure 1) for quantitative samples and dip net/hand picked collections from natural substrates for qualitative samples. Fish community sampling is conducted using a 5.7 m electrofishing boat (no figure available) having dual booms equipped with collapsible electrospheres. Power is supplied by a 7000 watt Smith-Root generator which powers a pulsed DC electrofishing unit. Other sampling methodologies (trawling, gill nets, beach seining, and hoop nets) were tested in the first years work and were found to be ineffective when compared to electrofishing. Fish sampling in Lake Erie proper is conducted at night while sites located in river mouths are sampled during day light. Three biological indices will be used initially to evaluate and rate biological performance. The Modified Index of well-being (originally developed by Gammon (1976) and subsequently modified by Ohio EPA (1988b)) is calculated as follows:

$$\mathrm{MIwb} = 0.5 \ln N + 0.5 \ln B + H(\mathrm{no.}) + H(\mathrm{wt.})$$

where:

N = relative numbers of all species excluding species designated "highly tolerant" by Ohio EPA (1987)

B = relative weights of all species excluding species designated "highly tolerant" by Ohio EPA (1987)

$H(\mathrm{no.})$ = Shannon diversity index based on species numbers

$H(\mathrm{wt.})$ = Shannon diversity index based on species weights.

The Invertebrate Community Index (ICI) and the Index of Biotic Integrity (IBI) will be modified from the present methodology utilized by Ohio EPA and employed for benthic macroinvertebrate and fish communities, respectively. The ICI is comprised of a suite of ten metrics based on community structure that are scored 0, 2, 4, or 6 depending on how closely the results approximate least disturbed reference conditions. A score of 6 approaches the highest quality community

Modified Hester-Dendy multiple-plate artificial substrate sampler used by the Ohio EPA for the quantitative collection of aquatic macroinvertebrates

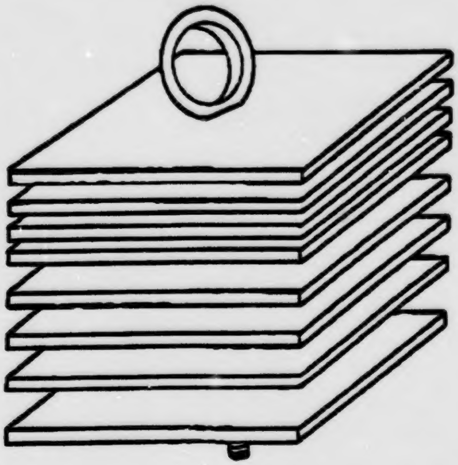

Figure 1.

conditions. Summation of the individual metric scores yields an ICI value between 0 and 60. The IBI is fundamentally similar to the ICI in that it is comprised of a series of metrics that are summed to yield a final score. Alternatively, it is composed of twelve metrics that include community structure, function and health indicators, and are scored 1, 3, or 5 which yields an IBI value between 12 and 60. The metrics presently used by the Ohio EPA, Karr's original metrics, and the possible alternative metrics being considered are listed below.

Karr's original metrics	Present OEPA metrics	Potential alternate metrics
# of species	# of species	Phytophilic species
# Darter species	% Round-bodied suckers*	Exotic species
# Sunfish species	# Sunfish species*	Lake associated species
# Intolerant species	# Sucker species*	Benthic species
% Green sunfish	# Intolerant species	Midwater species
% Omnivores	% Tolerant species	Native species
% Insectivorous cyprinids	%Omnivores	Wetland (estuary) species
% Piscivores	%insectivores	Planktivores
# Individuals	% Top carnivores	Molluscivores
% Hybrids	# Individuals	*Lepomis* species
% Diseased individuals	% Simple lithophils*	
	% DELT anomalies**	

* metrics under consideration for replacement
** DELT – deformities, eroded fins, lesions and tumors

Problems encountered thus far have been primarily associated with field methods. Every attempt must be made when locating artificial substrate samplers to minimize disturbance during the six week colonization period. Factors which can lead to the loss of samplers include: exposure to heavy wave action, deposition of sediments via long shore transport, and human disturbance. Collection of fish community data is best conducted during periods of off-shore winds. Heavy wave action drives fish into deeper water where they are not accessible by electrofishing. Even 30-60 cm waves make this type of sampling ineffective. After extended periods of strong on-shore winds a period of up to 2 weeks is needed before effective sampling can be conducted.

11. Degree of Environmental Intervention

Minimal temporal disturbance of resident fish communities.

12. Cost

The average cost (general Ohio EPA biological monitoring program) for the collection of community samples and their evaluation are as follows (Ohio EPA 1991):

Macroinvertebrate communities (per site);	
Artificial substrates	$824
Qualitative dip net	$275
Fish communities;	
Per sample	$340
Per site (3 pass)	$740

The previous cost estimates are derived from the Ohio EPA stream monitoring program and not from the Lake Erie nearshore biological criteria development project. Cost of criteria development are somewhat higher and do not reflect what would be expected from a standardized program. However the rate of sample collection and processing for Lake Erie sites appears to be comparable to the stream monitoring program thus cost should also be similar.

13. Biological Assessment

This project is focused on biological assessment. The reasoning behind our approach is the need for a standardized biological sampling method with which to evaluate the effects of habitat modifications throughout the Lake Erie area (dredging, filling, shoreline protection, etc.) and impacts from other types of pollution (including AOC and RAP associated studies). Derivation of lakewide criteria will permit evaluation of the quality of habitat proposed for alteration in comparison to the proposed change and it's known consequences (derived from previous studies). This will provide real world data that support government permitting decisions for proposed projects in a standardized, predictable way which can be easily understood by applicants and the concerned public. Within the data will also be found information on habitat types and their value to aquatic communities. The principle indicator of success will be the development of biological indicators and biological criteria for the Lake Erie nearshore area.

14. Measures of Success

Project still in progress. Progress presently on track.

Success Rating: 1

15. Key References

Fausch, D.O. 1984. Regional application of an index of biotic integrity based on stream fish communities. Trans. Amer. Fish Soc. 113: 39-55.

Gammon, J.R. 1976. The fish populations of the 340 km. of the Wabash River. Purdue Univ. Water Resources Res. Cen. Tech. Rep. 86. 73pp.

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Ohio EPA 1987a. Biological criteria for the protection of life: Volume I: The role of biological data in Water Quality Assessment. Ohio Environmental Protection Agency, Columbus, OH. 44p.

Ohio EPA 1987b. Biological criteria for the protection of life: Volume II: Users manual for biological field assessment of Ohio surface waters. Ohio Environmental Protection Agency, Columbus, OH. 229p.

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Ohio EPA 1989b. Biological criteria for the protection of life: Volume III: Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Ohio Environmental Protection Agency, Columbus, OH. 45p.

OEPA 1990. A preliminary assessment of Ohio's Lake Erie estuarine fish communities. Ohio Environmental Protection Agency, Columbus, OH. 27p.

OEPA 1991. The cost of biological field monitoring. Ohio Environmental Protection Agency, Columbus, OH. 5p.

Correct citation for this contribution:

Thoma, R.F., and McNight, C. 1995. Lake Erie biological criteria and habitat evaluation project, p. 191–196. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 33

1. Project Title: Sawquin Creek Marsh Channel Creation Project

2. Contact

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3. Agencies Involved

The project was done as a fisheries compensation agreement by the town of Rossmore. Monitoring was conducted by Ontario MNR, Canadian Wildlife Service and MRCA.

4. Restoration goal

To compensate for the loss of 585 m^2 of fish habitat from the construction of the Rossmore municipal water pipeline by creating spawning and nursery habitat for northern pike and other species.

5. Project Type

The expansion of an existing channel system by dredging new channels through a dense monoculture stand of cattails.

6. Background and Rationale

Sawquin Creek Marsh is a 1956 ha, Class 1 wetland located in Ameliasburgh Township on the Bay of Quinte. The wetland is dominated by extensive stands of monoculture cattails with low interspersion of open water, other vegetation forms and restricted fish use. Controlled water levels, the construction of causeways which reduced water flow, and land use practices that increased sediment and nutrient inputs to the marsh are thought to be the conditions that favoured cattail growth. Also, submergent macrophytes are thought to be limited on the Bay of Quinte due to low water clarity. The goal was to increase the amount of submergent vegetation and the interspersion of open water and emergent vegetation within a section of the marsh. This would create spawning and nursery habitat for several species of fish and feeding and breeding areas for marsh birds and herptiles.

7. Regulatory Considerations

A permit from the Ontario MNR to conduct work on shorelands was required.

8. Criteria

Several species of fish will migrate into shallow weedy channels to spawn (e.g., northern pike and yellow perch) or use as nursery habitat (e.g., largemouth bass, brown bullhead (*Ictalurus nebulosus*)). Channels had to be deep enough to ensure fish access spring through the fall, and constructed to provide a maximal amount of edge.

9. Project Design

Channels formed interconnecting loops approximately 3 m wide and 0.75-1 m deep during spring and early summer conditions. Dredged material was piled beside the channels to provide a substrate on which a variety of wetland plants could grow.

10. Implementation

A total of 380 m of channel were created resulting in an improved wetland area of 2 320 m^2 and 720 m of edge. The channels were dug in August 1992 using a floating backhoe. due to the sponginess of the substrate (Peat/muck), approximately 3 m had to be removed to create a channel 1 m deep. Dredged material was piled on the sides of the channels.

11. Degree of Environmental Intervention

Approximately 1 140 m^2 of cattails were converted to submergent marsh due to the dredging. More cattails (approximatly 775 m^2) were also lost from piling dredged material on top of them, but were replaced by other emergent plants (and new cattails) in following years. Due to the timing of the work (August) it is unlikely that breeding fish or wildlife were affected.

12. Cost

Contracting of floating backhoe and operator:	$2 040.00
Cost per metre of channel:	$5.37
Cost per m^2 of habitat:	0.88

13. Biological assessment

Observations of wildlife use of the channels were conducted in the summer of 1993. In 1994, a comparison of the use of the dredged area and solid cattail stands by marsh birds based on vocalizations was conducted. Fish use of the channels and solid cattails stands was compared based on catch per unit effort using windemere traps in 1994.

14. Measures of Success

Great blue herons, american bitterns, mallards, wood ducks, leopard and green frogs and signs of deer and other birds were observed at the dredged site. However, no comparison with a non-altered site was conducted (Hartley 1993).

No significant difference in the use of the channels and dense cattails was found in swamp sparrows, marsh wrens, and red-winged blackbirds (Weseloh et al. 1994).

Fisheries assessment revealed that catch per unit effort and species richness were greater in the artificial channels than in the dense cattails. Channels were used as nursery habitat by northern pike, largemouth bass and other species. Central mudminnows were the only species found in the cattails (Smith and Cope 1994).

Success Rating: 4 – based on the fisheries evaluation.

However, the life span of the channels is unknown. It is likely that without maintenance, channels will fill-in in the future and return to their previous state.

15. Key References

Hartley, K. 1993. An evaluation of 5 coastal marsh restoration projects in the Bay of Quinte region. Unpublished report, Moira River Conservation Authority, Belleville, Ontario.

Smith, A. and Cope, L. 1994. Fisheries assessment of some wetland enhancement projects in the Quinte area. *In* A. Smith. 1994. Proceedings of the workshop on the creation of channels and ponds within cattail marshes on the Bay of Quinte, and a conceptual plan. Unpublished report, Ontario Ministry of Natural Resources, Napanee, Ontario.

Weseloh, D.V., Patrikeev, M., Richardson, M., and Blokpoel, H. 1994. Studies of marsh and waterbirds on the Bay of Quinte, 1994. *In* A. Smith. 1994. Proceedings of the workshop on the creation of channels and ponds within cattail marshes on the Bay of Quinte, and a conceptual plan. Unpublished report, Ontario Ministry of Natural Resources, Napanee, Ontario.

Correct citation for this contribution:

Mathers, A., and Hartley, K. 1995. Sawquin Creek marsh channel creation project, p. 197–199. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 34

1. **Project Title: Strawberry Island (Niagara River) Shoreline Habitat Restoration and Protection Project**

2. **Contacts**

   Strawberry Island is located in U.S. waters of the Upper Niagara River and is owned and administered by New York State Office of Parks, Recreation and Historic Preservation (NYSOPRHP), Western District, Niagara Frontier Region. The NYSOPRHP contact is:

   Mr. Rolfe Steck
   New York State (NYS) Office of Parks, Recreation and Historic Preservation,
   Niagara Reservation State Park, P.O. Box 1132, Niagara Falls, New York 14303
   Tel.: (716) 278-1718

   This project description was prepared by:
   Ms. E. Ann Poole
   U.S.Fish and Wildlife Service, Lower Great Lakes Fisheries Resource Office,
   405 North French Road, Suite 120A, Amherst, NY 14228
   Tel.: (716) 691-5456; FAX (716) 851-6154

   Mr. Michael Wilkinson
   New York State Department Environmental Conservation,
   Region 9 Fisheries Unit, 270 Michigan Avenue, Buffalo, NY 14203
   Tel.: (716) 851-7010; FAX (716) 851-7008

3. **Agencies**

   a. Federal
   U.S. Department of Agriculture Natural Resources Conservation Service (formerly Soil Conservation Service), East Aurora, NY Field Office and Big Flats, NY Plant, Material Centre

   U.S. Army Corps of Engineers, Buffalo District

   U.S. Fish and Wildlife Service, Lower Great Lakes Fisheries Resources Office

   b. State
   NYS Assemblyman Robin Schimminger

   NYS Department of Environmental Conservation, Region 9

NYS Office of Parks, Recreation and Historic Preservation
Western District – Niagara Frontier Region

c. County
Erie County Soil and Water Conservation District

Erie County Legislator Charles Swanick

d. Non-Government partners
American Society of Civil Engineers, Buffalo Chapter

Niagara Mohawk Power Corporation

Strawberry Island Preservation Group

United Auto Workers Local 774

Private donations and voluntary assistance

4. Restoration Goal

The project goal was to maintain ecosystem function by restoring a severely eroded shoreline habitat on Strawberry Island and providing protection against further erosion and habitat degradation.

5. Project Type

Shoreline habitat restoration and stabilization.

6. Background and Rationale

Strawberry Island is located in the Upper Niagara River near Buffalo, New York. The island is narrow and horseshoe-shaped with the closed end facing upstream. It is located at the upstream end of the largest littoral habitat in the Niagara River. The island's present shape is due to gravel mining activities which substantially reduced the area of upland habitat.

The aquatic habitat associated with Strawberry Island is an extensive (approximately 162 ha) area of riverine shoals (generally less than 1.8 m deep below mean low water) containing beds of submergent aquatic vegetation. Wild celery (*Vallisneria*) is an important component of the plant community. The lagoon located within Strawberry Island is a deeper lentic habitat providing refuge from river currents.

The Strawberry Island shallows are a significant fish spawning and nursery area. Studies during the mid-1970's indicated this was one of two principal spawning grounds for muskellunge in the Niagara River. Recent surveys (1992 and 1993) indicate the lagoon is the River's most productive muskellunge nursery habitat. The lagoon provides habitat for many other species of fish including northern pike, yellow perch and largemouth and smallmouth bass. Lake Sturgeon (federally listed category 2 candidate, NYS listed threatened) occur in the Upper Niagara River and may use the shoals for feeding or other biological functions.

The Strawberry Island Shoals are one of the most important waterfowl wintering areas (November-March) in the northeastern United States, especially for diving ducks. Mid-winter aerial surveys of waterfowl abundance for the ten-year period 1976-1985 indicate average concentrations of over 14 000 birds in the upper Niagara River each year (25 371 in peak year), including approximately 8 500 common and red-breasted mergansers (17 470 in peak year), 2 600 common goldeneye (8 520 in peak year), 1 900 canvasbacks (5 000 in peak year), and 1 200 scaup (2 306 in peak year), along with lesser numbers of black duck, mallard, bufflehead and oldsquaw. The shoals serve as a major feeding and resting area for these birds. The habitat is located in one of the few major wintering areas for canvasbacks in New York State. Waterfowl use of the area during winter each year is influenced, in part by the extent of ice cover throughout the region.

Strawberry Island is used for breeding by Canada geese and two species of gulls. The island and adjacent shallows are used for resting and feeding by common terns (federally listed category 2 candidate-Great Lakes population, NYS listed threatened). The island provides one of the few relatively isolated resting habitats available in the upper Niagara River for birds such as great blue, black-crowned night and green-backed herons.

In spring 1993, erosion caused by ice/wave action resulted in an approximately 15 m wide breach of the southwest arm of the island. Additional erosion was caused by watercraft traversing the breach. Continued erosion would have degraded additional shoreline habitat and potentially jeopardized the physical integrity of the remainder of the island and its lagoon. The island probably affords protection from erosion for the large complex of shallow water habitat downstream of the island. Loss of the island, in whole or in part, would likely result in degradation of the productive shallow water habitat.

7. Regulatory Considerations

The project required a U.S. Army Corps of Engineers Nationwide Permit No. 13 for bank stabilization. The project received Section 401 water quality certification with the Nationwide Permit. The project applicant (NYSOPRHP) was exempt from a New York State Protection of Water Permit. NYSOPRHP filed a NYS Department of State Coastal Management Program Federal Consistency Assessment Form for the project.

8. Criteria

Habitat criteria for designing the project were:

a. Restore and protect waterbird nesting, resting and feeding habitat;
b. Protect fish spawning, nursery and foraging habitat;
c. Restore and protect a shrub, grass and herbaceous cover type composed of native and naturalized plant species;
d. Improve aesthetics;
e. Discourage human activity which could result in habitat degradation and disturbance of wildlife.

9. Project Design

The project was designed to restore the pre-existing shoreline habitat lost to erosion, and to protect the restored habitat against further erosion.

10. Implementation

The project consisted of four tasks as follows:

Task	Description
Task 1	Beach repair
Task 2	Lagoon beach rip-rap
Task 3	Outer beach strengthening
Task 4	Revegetation plantings

The first three tasks were heavy construction activities and the last task was conducted with hand labour. On-site construction for Tasks 1-3 started December 8, 1993 and ended December 27, 1993. Task 4, revegetation plantings, took place on May 10, 1994.

Tasks 1-3 consisted of placing a high tensile strength geo-fabric foundation blanket on native soil, covering the geo-fabric with bedding material, and covering with NYS Department of Transportation medium stone (15-30 cm) to achieve project specifications. NYS Department of Transportation light stone (5-7.5 cm) was used for the core of the breach repair (Task 1) and for filling voids in the outer beach rip-rap (Task 3). The core of the onshore breakwater received a veneer of soil (high in organic matter) for plantings. The soil material was recovered from the lagoon. The stone and geo-fabric were carefully keyed into native soil along the beach and lagoon. Slopes, curves and breakwater alignment were carefully graded to simulate natural contours and shapes.

Quantities of materials used were 766 m^2 of geo-fabric, 106 m^3 (189 mT) of light stone and 488 m^3 (868 mT) of medium stone. The stone material used was locally-mined and crushed dolomitic limestone. The geo-fabric was woven polypropylene material, minimum 203 g per m^2, equivalent to Marafi Brand, Type 700X.

Approximate dimensions of the individual tasks, as designed, were as follows:

Task	Description	Length	Width
Task 1	Breach repair	38 m	12-15 m
Task 2	Lagoon beach rip-rap	30 m	0-6 m
Task 3	Outer beach strengthening	27 m	6 m
Task 4	Revegetation plantings	24 m	6 m

The as-built project provided additional outer shoreline protection as some in-field decisions and agreements with the contractor and regulatory agencies were made as work progressed. Due to the logistics of materials handling and the need to move a large crane to the beach, a stockpile of rip-rap materials was placed between original Tasks 1 and 3. The agreement included placement of rip-rap in the specified fashion at this new location, including the geotextile foundation course. The as-built project achieved a total of nearly 106 m of continuous outer shoreline protection, with fewer end sections and a cleaner look to the final product.

Engineering drawings for Tasks 1-3 are provided in Appendix 1, these drawings were employed in the permitting process.

The Contracted Scope of Work, which included a high degree of "regulatory guidance material" for (mandatory) use by the contractor, was developed by project partners in numerous planning meetings. This critical construction Quality Assurance/Quality Control document is provided as Appendix 2. It reflects a great number of environmental impact issues that were mitigated through the quality assurance/quality control practices and work sequence required.

The revegetation plantings were performed manually using volunteers during a one-day work period. Plants selected for the project included shrubs, grasses and herbaceous species. Plant propagation forms included wattles, seeds and young plants (some as rooted plugs). The materials were planted in a strip of soil placed on the long axis of the breach repair core. Soil depth was approximately 0.9 m at its greatest depth. Plantings were mulched with straw. The planting plan and a description of the stabilization project are provided in Appendix 3.

Signage was erected to regulate recreational activities and foot traffic that could cause additional erosion and wildlife disturbance.

Problems in Implementation

The project site was located on an island in the Niagara River, and all equipment, materials and project personnel were transported to and from the site via heavy watercraft. This necessitated additional logistics planning and added to project costs.
Shallow water adjacent to the project site necessitated dredging an access channel for the work barges. The access channel was approximately 46 m long and was excavated perpendicular to river flow to avoid directing swift river currents into the work site. Dredged material was sidecast downstream of the access channel to facilitate refilling upon project completion. The access channel required deepening after its initial construction to avoid damage to tug propellers due to a decrease in River water level. The necessity for dredging the access channel added significantly to the cost of the project.

The stone fill material was double-handled thus substantially increasing time and labor required for the project.

The presence of dangerous currents and cold-water danger caused concerns for worker safety and potential loss or damage to equipment. There were substantial concerns about possible death and liability for damages. These concerns, coupled with many unique aspects of the project, caused many catches in project administration including difficulties insuring protection of all parties.

Many bare-rooted shrub seedlings did not survive, and grasses planted as rooted plugs, such as beach grass and cord grass, could not be located during monitoring at the planting site. It is believed that gulls or other wildlife removed buds from shrubs and uprooted grass plugs.

Several cottonwood saplings, which did not conform to the planting plan, were donated and planted on the breach repair later in the growing season.

December weather caused some difficulties for work crews in project construction but no significant delays. The need to complete construction prior to severe storms and ice formation caused anxiety for project personnel and contractors. The first major winter storm struck the Buffalo area upon project completion.

11. Degree of Environmental Intervention

The scale of the project dictated use of heavy construction equipment. The stone used for the onshore breakwater and rip-rap was obtained from a local quarry. However, crushed limestone is obviously not a native material along Niagara River beaches and shorelines. The quarried limestone was used to ensure that project specifications were met, and to alleviate any contamination concerns for materials placed at the site.

Dredging the access channel for the work barges did not produce any notable instances of excessive turbidity. Human activity during revegetation plantings in May disturbed some bird nesting activity.

12. Cost

The total 'market value' of this project, approximately $61 000 (U.S.), is provided below. The 'actual' cost can be obtained by deducting items with an asterisk. These items consisted mostly of agency staff time and non-billable donations.

a. Engineering/Design Costs

Item	Cost($U.S.)
Planning meetings (estimated)	$5 000*
Engineerings, design, permits (estimated)	$5 000*

b. Construction Costs-Materials and Labor

Item	Cost($U.S.)
Contractor	$28 250
Medium and light stone	$13 400
Geofabric foundation	$3 000
Landside staging area	not available*
Vegetation for plantings	$500*
Labor for plantings	$1 250*
Regulatory oversight (estimated)	$1 000*
Project supervision (estimated)	$2 000*

c. Assessment and Monitoring

The project was designed primarily to prevent additional habitat degradation of the Island, lagoon and adjacent shallows. Assessment and monitoring activities consisted primarily of several site inspections to assess success of revegetation plantings and to monitor post-project responses.

Item	Cost($U.S.)
Site inspections (estimated)	$1 000*

13. Biological Assessment

a. Rationale

The project was designed to restore an eroded portion of Strawberry Island and to protect the Island and shoal complex from further erosion. The preventative nature of the project largely precluded the need for monitoring biota, except for revegetation plantings.

b. Methods

Plantings were inspected during summer and fall to determine if they survived the planting procedure and first growing season.

c. Results

Many plantings survived the first growing season and established a vigorous shrub, grass and herbaceous cover type on the breach repair. Redtop grass was very successful in establishing on the site. One row of willow wattles planted in stone material adjacent to the soil strip did not survive, probably due to exposure.

14. Measures of Success

The project was successful in restoring the breach shoreline habitat and preventing further erosion in the breach area.

The project demonstrated that stakeholders from a variety of public agencies and the community can work effectively as a team toward achieving a common goal.

The project exceeded expectations that the project could be implemented, and that it could be implemented on schedule. Other areas of Strawberry Island are continuing to erode and further stabilization work is needed. The stakeholders remain interested in the necessary preservation effort and promote this need whenever possible. Long-term planning is required to devise and implement appropriate preservation measures for this fragile habitat, highly at risk due to its tenuous location.

Success Rating: 4

15. Key References

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Acres International Corporation. 1988. Strawberry Island draft report. 140 John James Audubon Parkway. Amherst, New York.

Buffalo News. May 1, 1993. "Erosion of Strawberry Island is increasing, biologist says."

Buffalo News. December 13 1993. "Citizens agencies unite to save Strawberry Island". Article by Mike Vogel

Harrison, E.J. 1978. Comparative ecologic life histories of sympatric populations of Esox lucius and Esox masquinongy of the upper Niagara River and its local watershed. PhD dissertation. State University of New York at Buffalo.

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New York State Department of State. Significant coastal fish and wildlife habitat rating form for Strawberry Island - Motor Island Shallows.

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Schoellkopf Geological Museum and New York State Office of Parks, Recreation and Historic Preservation. 1990. Strawberry Island site evaluation. 12 pages.

United States Fish and Wildlife Service. Great Lakes Fisheries Research Office. Monthly progress reports, August, 1993 to October, 1994. Amherst, New York.

Zenkert, Charles. 1934. The flora of the Niagara Frontier Region; ferns and flowering plants of Buffalo and vicinity. Bulletin of the Buffalo Society of Natural Science. Volume XVI.

Correct citation for this contribution:

Steck, R., Poole, A., and Wilkinson, M. 1995. Strawberry Island (Niagara River) shoreline habitat restoration and protection project, p. 200–230. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Appendix 1

Strawberry Island Emergency Project

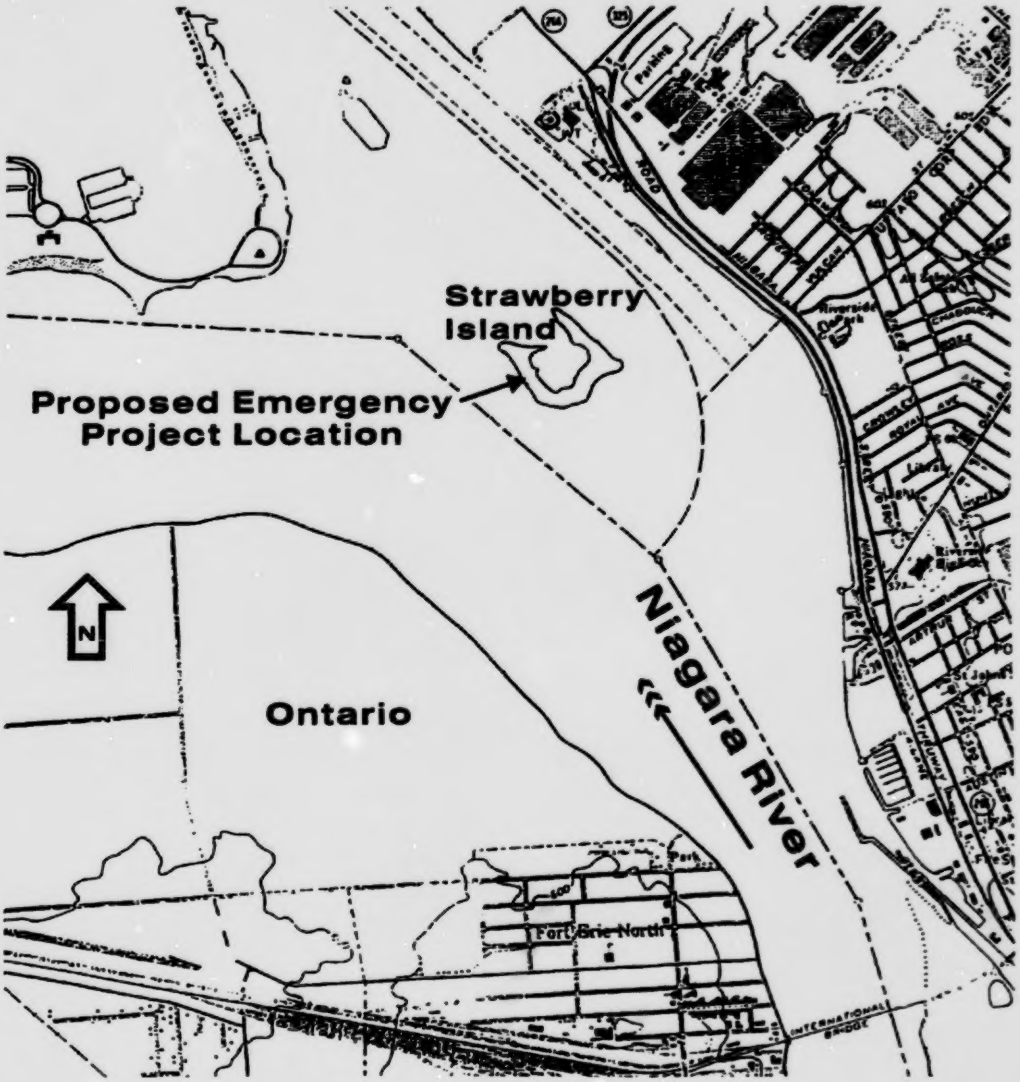
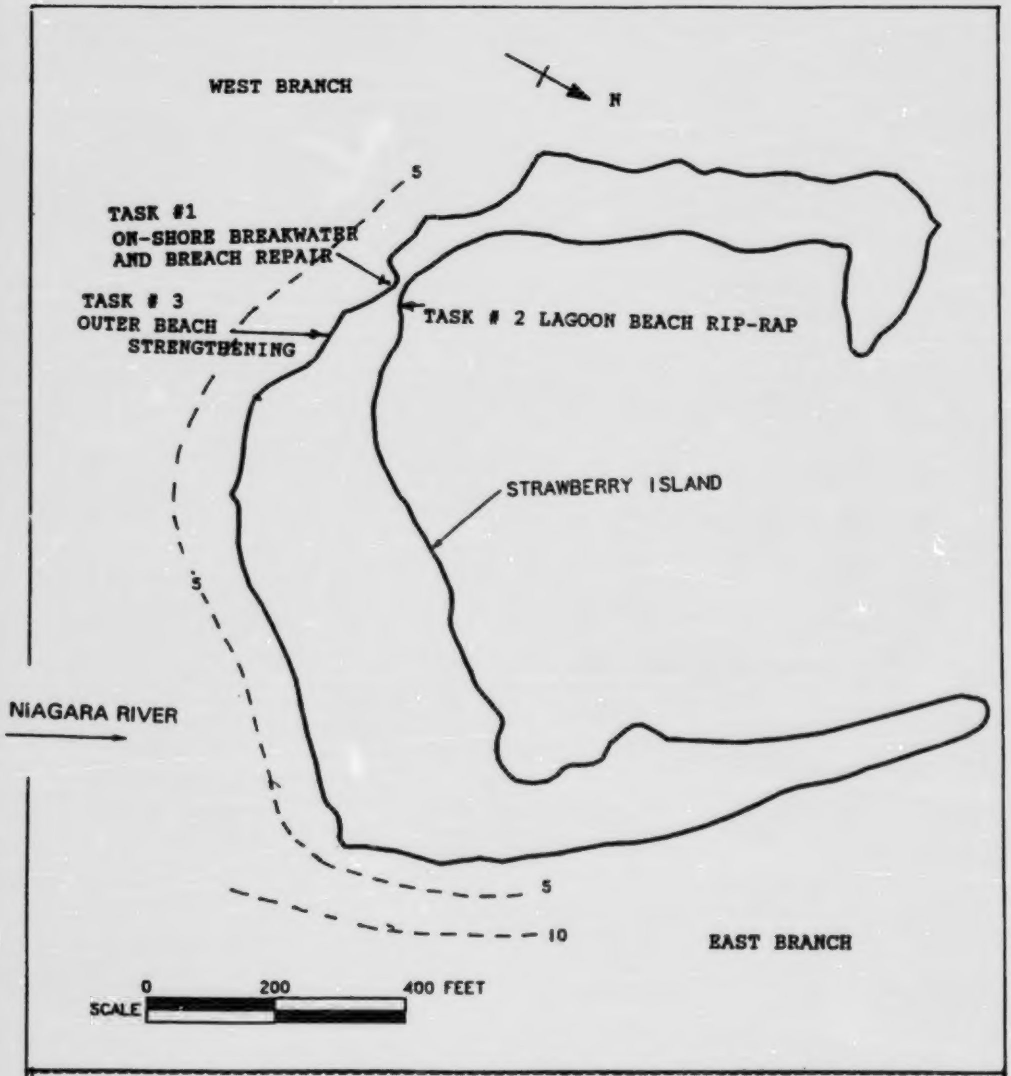

Strawberry Island
Proposed Emergency Project Location
N
Ontario
Niagara River
Fort Erie North
International Bridge

Figure 1.


WEST BRANCH
N
5
TASK #1
ON-SHORE BREAKWATER
AND BREACH REPAIR
TASK # 3
OUTER BEACH
STRENGTHENING
TASK # 2 LAGOON BEACH RIP-RAP
STRAWBERRY ISLAND
5
NIAGARA RIVER
5
10
EAST BRANCH
0
200
400 FEET
SCALE

NEW YORK STATE OFFICE OF PARKS, RECREATION AND HISTORIC PRESERVATION

STRAWBERRY ISLAND EMERGENCY PROJECT

LOCATION: NIAGARA RIVER
DRAWN BY: RHS
CHECKED BY: DAV
PURPOSE: APPROXIMATE TASK
LOCATIONS

SHEET TITLE: TASK LOCATIONS MAP

DATE: SEPTEMBE

NYSOPRHP
(Strawberry Island)
DA Proc. No. 93-620-15
Sheet 2 of 7

Figure 2.

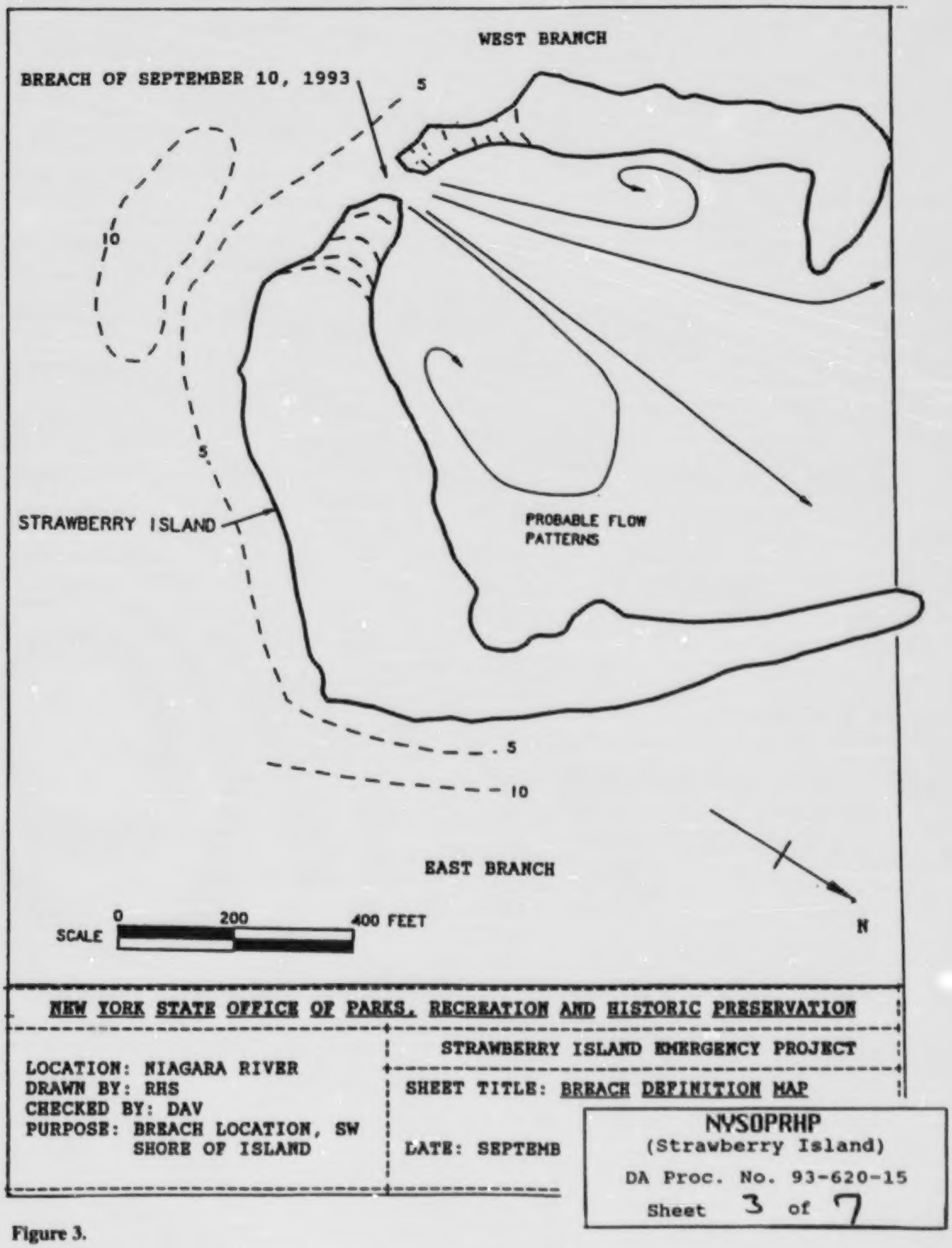

WEST BRANCH
BREACH OF SEPTEMBER 10, 1993
5
10
5
STRAWBERRY ISLAND
PROBABLE FLOW PATTERNS
5
10
EAST BRANCH
N
SCALE
0
200
400 FEET
NEW YORK STATE OFFICE OF PARKS, RECREATION AND HISTORIC PRESERVATION
STRAWBERRY ISLAND EMERGENCY PROJECT
LOCATION: NIAGARA RIVER
DRAWN BY: RHS
CHECKED BY: DAV
PURPOSE: BREACH LOCATION, SW SHORE OF ISLAND
SHEET TITLE: BREACH DEFINITION MAP
DATE: SEPTEMB
NYSOPRHP
(Strawberry Island)
DA Proc. No. 93-620-15
Sheet 3 of 7

Figure 3.

Strawberry Island Emergency Project

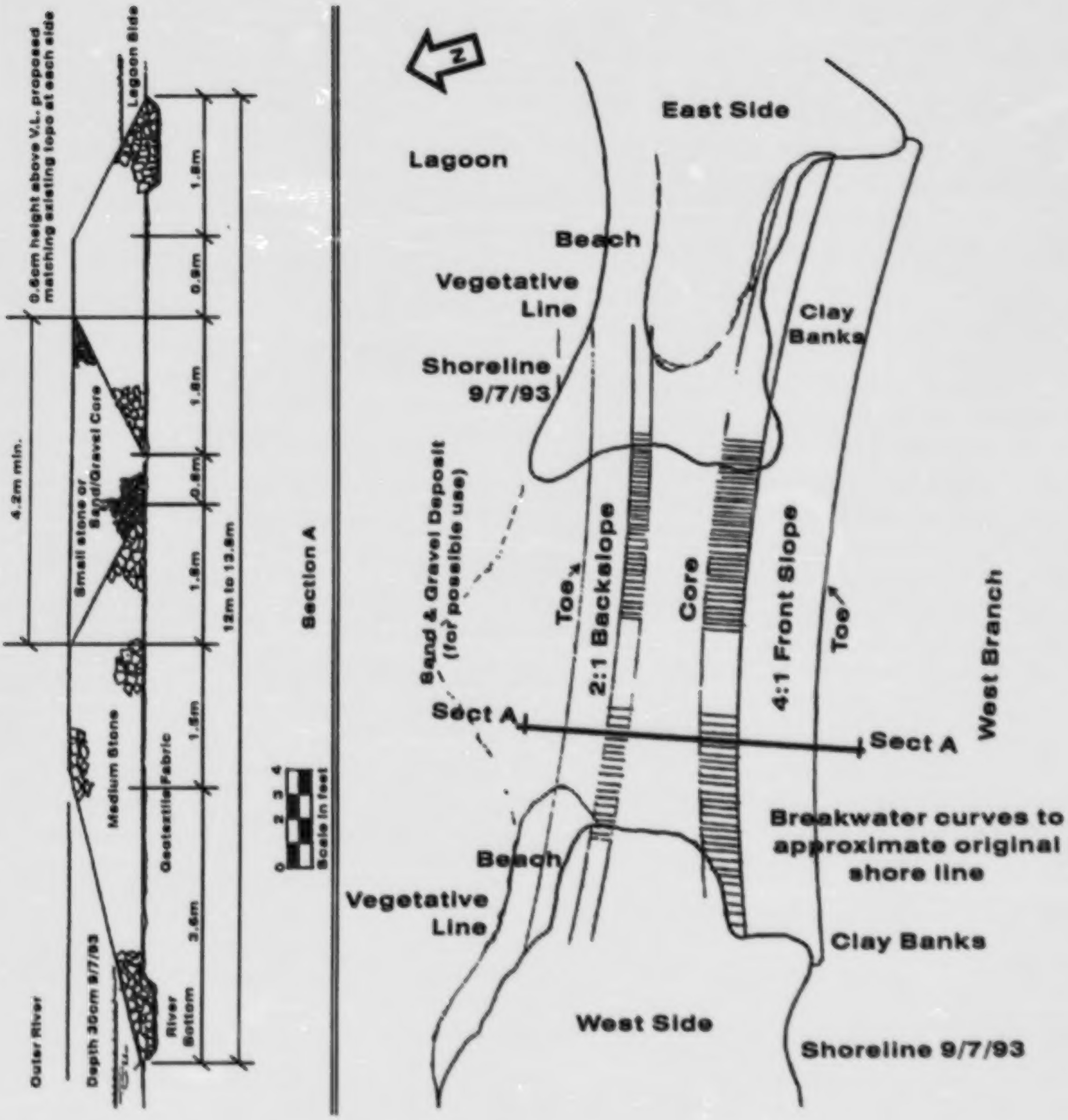
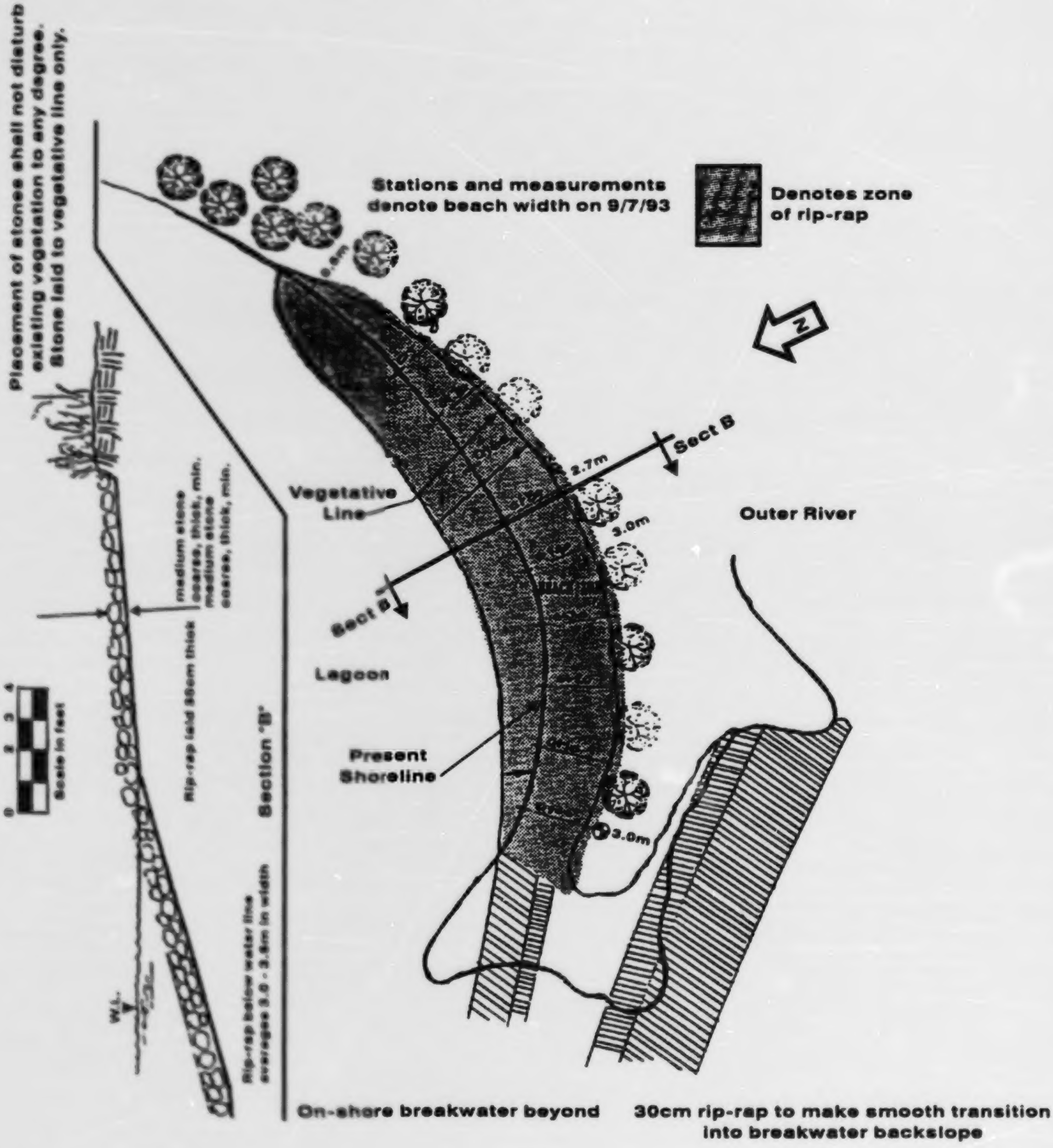

0.6cm height above V.L. proposed matching existing topo at each side
Lagoon Side
4.2m min.
Small stone or Sand/Gravel Core
Medium Stone
Geotextile Fabric
Outer River
Depth 30cm 9/7/93
River Bottom
1.8m
0.9m
1.8m
0.8m
1.8m
1.5m
3.6m
12m to 12.8m
Section A
0 2 3 4
Scale in feet
N
East Side
Lagoon
Beach
Vegetative Line
Shoreline 9/7/93
Clay Banks
Sand & Gravel Deposit (for possible use)
Toe
2:1 Backslope
Core
4:1 Front Slope
Toe
West Branch
Sect A
Sect A
Breakwater curves to approximate original shore line
Beach
Vegetative Line
Clay Banks
West Side
Shoreline 9/7/93

Figure 4.



Strawberry Island Emergency Project

Placement of stones shall not disturb existing vegetation to any degree. Stone laid to vegetative line only.
medium stone coarse, thick, min.
medium stone coarse, thick, min.
Rip-rap laid 30cm thick
Section "B"
0 1 2 3 4
Scale in feet
W.L.
Rip-rap below water line averages 3.0 - 3.6m in width
Stations and measurements denote beach width on 9/7/93
Denotes zone of rip-rap
N
Sect B
2.7m
3.0m
Sect B
Vegetative Line
Outer River
Lagoon
Present Shoreline
3.0m
On-shore breakwater beyond
30cm rip-rap to make smooth transition into breakwater backslope

Figure 5.

Strawberry Island Emergency Project

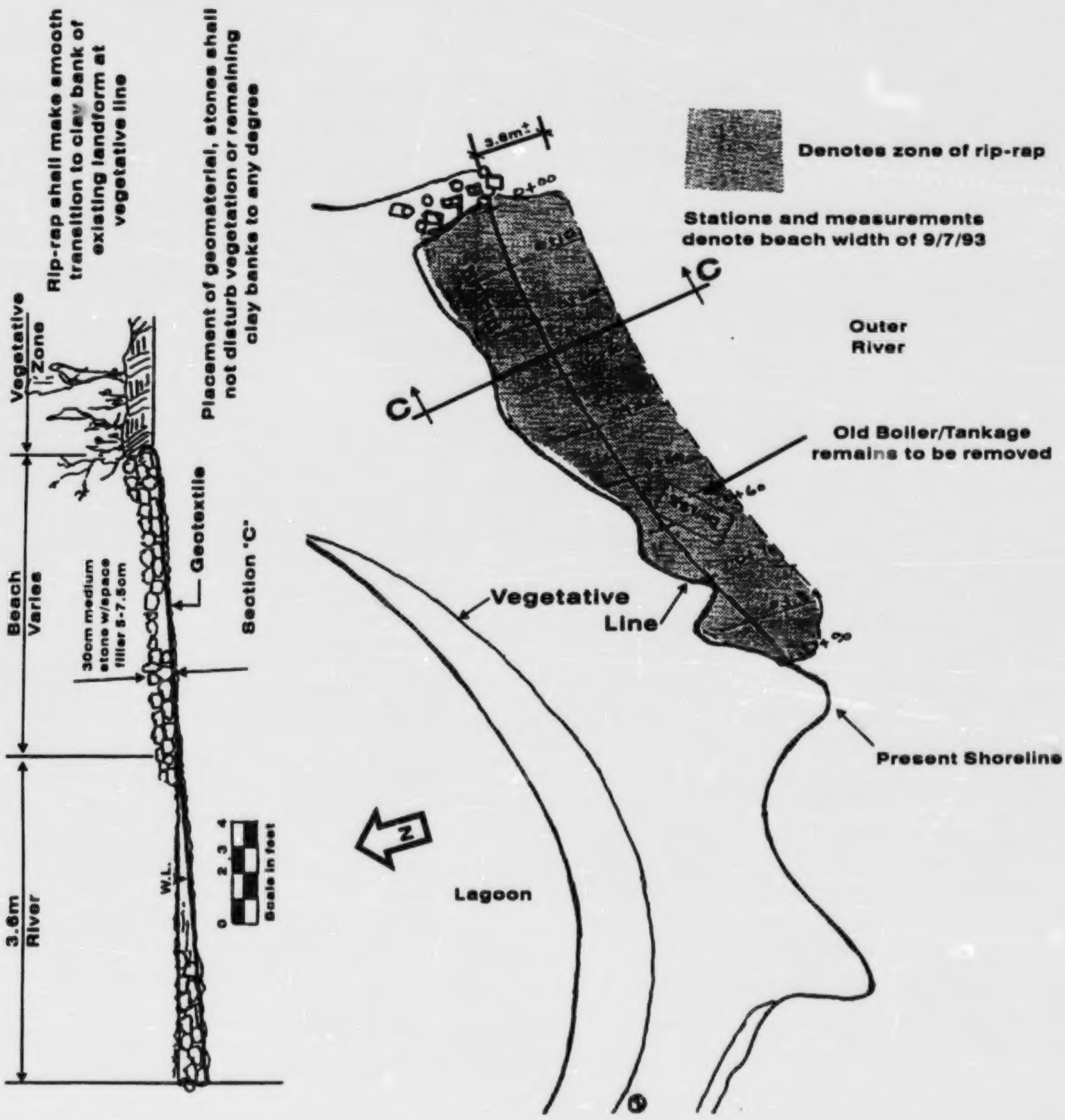
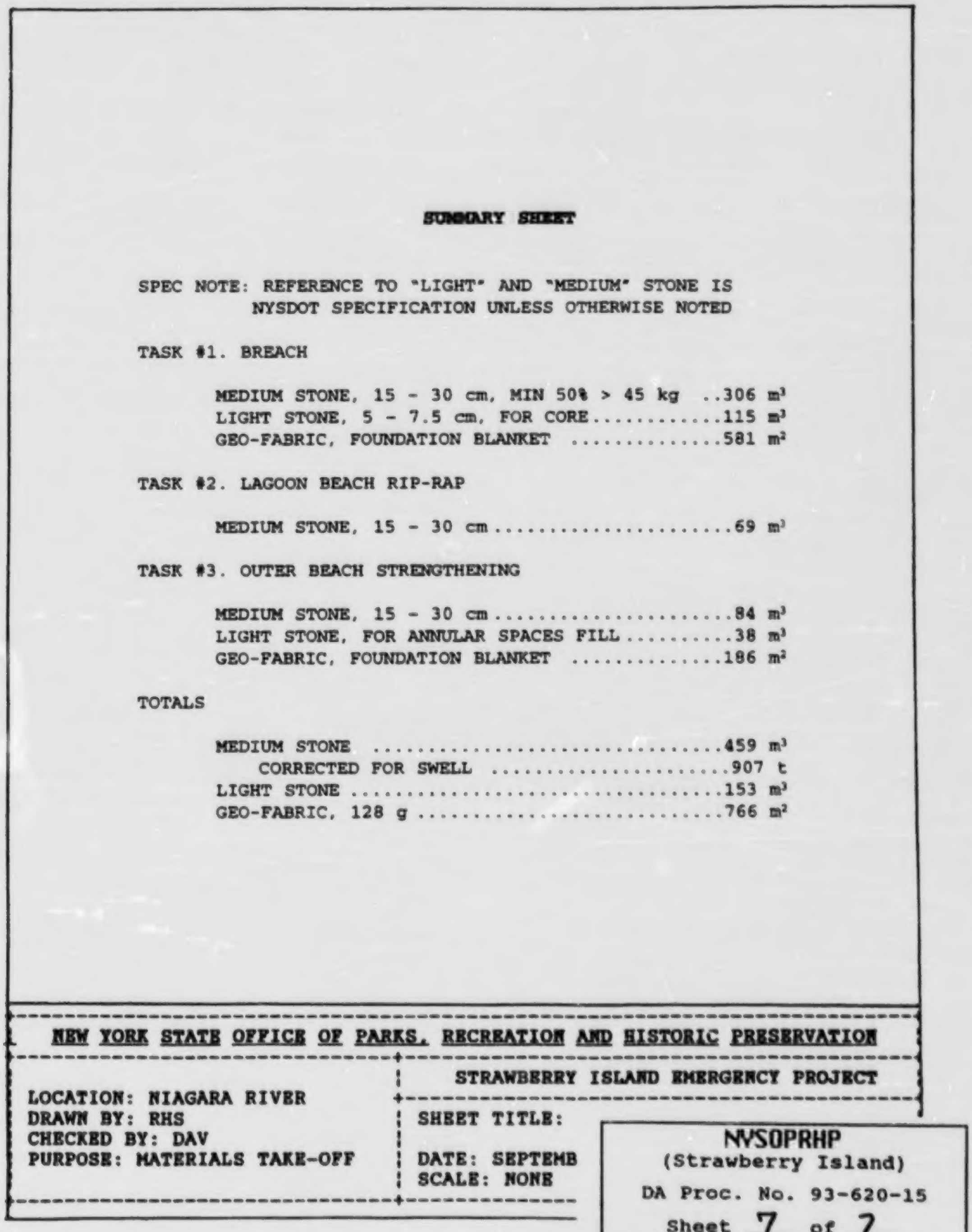

Rip-rap shall make smooth transition to clay bank of existing landform at vegetative line
Placement of geomaterial, stones shall not disturb vegetation or remaining clay banks to any degree
Vegetative Zone
Beach Varies
3.6m River
30cm medium stone w/space filler 5-7.5cm
Geotextile
W.L.
Section 'C'
0 2 3 4
Scale in feet
3.6m±
0+00
C
C
Denotes zone of rip-rap
Stations and measurements denote beach width of 9/7/93
Outer River
Old Boiler/Tankage remains to be removed
Vegetative Line
Present Shoreline
N
Lagoon

Figure 6.



SUMMARY SHEET

SPEC NOTE: REFERENCE TO "LIGHT" AND "MEDIUM" STONE IS NYSDOT SPECIFICATION UNLESS OTHERWISE NOTED

TASK #1. BREACH

MEDIUM STONE, 15 - 30 cm, MIN 50% > 45 kg	306 m^3
LIGHT STONE, 5 - 7.5 cm, FOR CORE	115 m^3
GEO-FABRIC, FOUNDATION BLANKET	581 m^2

TASK #2. LAGOON BEACH RIP-RAP

MEDIUM STONE, 15 - 30 cm	69 m^3

TASK #3. OUTER BEACH STRENGTHENING

MEDIUM STONE, 15 - 30 cm	84 m^3
LIGHT STONE, FOR ANNULAR SPACES FILL	38 m^3
GEO-FABRIC, FOUNDATION BLANKET	186 m^2

TOTALS

MEDIUM STONE	459 m^3
CORRECTED FOR SWELL	907 t
LIGHT STONE	153 m^3
GEO-FABRIC, 128 g	766 m^2

NEW YORK STATE OFFICE OF PARKS, RECREATION AND HISTORIC PRESERVATION

STRAWBERRY ISLAND EMERGENCY PROJECT

LOCATION: NIAGARA RIVER
DRAWN BY: RHS
CHECKED BY: DAV
PURPOSE: MATERIALS TAKE-OFF

SHEET TITLE:
DATE: SEPTEMB
SCALE: NONE

NYSOPRHP
(Strawberry Island)
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Figure 7.

Appendix 2

Attachment to contract – Scope of work
Dated 12/1/93

Project Identification

Project: Strawberry Island Emergency Project
Date: December 1993
Location: Strawberry Island
Waterway: Niagara River
(T) Grand Island, Erie Country, New York
Permit: Department of Army,
Buffalo District Corps of Engineers
Application No. 93-620-15, Nationwide Permit
Effective Date – September 24,1993

Scope of Work
(Dated December 1, 1993)

A. Project Background and Task Focus

The Corps of Engineers (COE) Permit captioned above is a key document in the performance of the Work. As such, it is included as an Addendum or Attachment to the private contract that authorizes the Work. This Scope of Work review also, is an important Contract Document element, and is intended to be integrated within the body of the contract, or included as an Addendum or Attachment to contract.

Permit Task Descriptions

The COE Permit, as written, contains three (3) specific Work Tasks, entitled and briefly described as follows:

1. Task #1 *On-Shore Breakwater and Breach Repair*

Task #1 consists of the placement of geotextile fabric throughout the full "footprint" of the breakwater, placement of bedding material upon the fabric, placement of NYSDOT Medium stone to

construct the front and rear walls of the breakwater, placement of NYSDOT Light stone as core of the central portion of the breakwater and a topping of the core with available dredged organic materials that will be used in future months to establish vegetative cover (BY OTHERS).
The design estimated volumes for Task #1 of the Work are as follows:

TASK #1
306 m^3 of NYSDOT Medium Stone;
115 m^3 of NYSDOT Light Stone;
581 m^2 of geotextile fabric.

The on-shore breakwater lines, grade, cross-sections and all other physical detail are to be constructed in substantial conformance with COE Permit Drawing Sheet 4 of 7.

2. Task #2 *Lagoon Beach Rip-Rap*

Task #2 consists of the placement of NYSDOT Medium Stone along the lagoon beachline, on the beach and within the shallows, starting from the northeasterly corner of new breach repair/breakwater location, running in the easterly direction, for approximately one hundred feet (100').

The design estimated volume for Task #2 of the Work is as follows:

TASK #2 69 m^3 of NYSDOT Medium Stone.

Task #2 construction shall be in substantial conformance with the detail of COE Permit Drawing Sheet No. 5 of 7.

3. Task #3 *Outer Beach Strengthening*

Task #3 consists of the placement of specified materials along a beachline and into the shallows in front of this same beachline located to the east (upstream) of the breach repair location. This Task shall be constructed in substantial conformance with the COE Permit Drawing Sheet No. 6 of 7.

An old boiler tank (landmark of subject beach) shall be removed from the Island for Contractor disposal.

The design estimated volumes for Task #3 of the Work is as follows:

TASK #3
84 m^3 of NYSDOT Medium Stone;
38 m^3 of NYSDOT Light Stone;
186 m^2 of Geotextile Fabric.

Specification Notation: Material Specifications are NYSDOT Standard Specification Section 620 materials as provided in the January 2, 1990 Edition of Construction Standards.

B. Summary Overview of the Work and Special Conditions

Work Elements Included

The Work to be performed includes mobilization & demobilization, furnishing all the necessary labor, machinery, vessels, transport of personnel, materials and supplies to the Island, heavy equipment necessary, associated fuels and supplies, and all incidental associated services to accomplish the construction of all three (3) Work Tasks as described in COE Permit and as further described in this Scope of Work review.

Contract Documents Overview

The COE Permit includes approved design detail drawings and specifications of specific bank stabilization and breach
correction methods, as well as various Nationwide Permit terms and conditions that must be followed in working in the marine environment of the project. The cited COE Permit, the executed Permit to Work on State Lands, this Scope of Work review and the Private Contract between project sponsors and Contractor form the primary body of Contract Documents that govern the Work.

Specified Materials by Others

The NYSDOT Specification "Medium" and Light stone and geotextile foundation material, which are the primary building materials of the Work, are provided by OTHERS. Subject materials are available to the Contractor to the estimated volumes (maximum) as estimated by design engineer and as reviewed in Section A above. These materials shall also be delivered by OTHERS to a convenient riverside site (i.e., contractors yard in N.Tonawanda, NY or some other mutually agreeable site such as the "Old Wickwire Plant Site") for Contractor materials management, loading and transport to Strawberry Island.

Transport of Materials to Island Included

The Work includes the furnishing of personnel, machinery, vessels, fuels and all the necessary associated services to manage and load the delivered stone, to the maximum estimated volumes, onto barges and transport materials, provided by OTHERS, directly to the project site.

Materials Management and Volumes Monitoring as Relates to Project Scope

The Contractor is responsible to directly order all stone materials against a standing purchase requisition (to be paid by OTHERS) to meet his construction schedule. The Contractor has certain other important "materials management" responsibilities in regards to material volumes being delivered that are the subject of "Section C" of this Scope that follows. "Section C" outlines a procedure, whereby the Oversight Engineer may determine, based on factual evidence provided by the Contractor, to reduce project Scope. Reduction in Scope may be allowed in the instance where materials in excess of design estimates are actually needed to accomplish the original, Scope of Work, i.e., all three Tasks, as permitted.

Other Permits/Approvals/Authorizations

The COE Nationwide Permit and State Authorization to Work on State Lands Permits do not obviate the need by the Contractor to obtain other necessary Federal, State, or local permits, approvals or authorizations required by law, for this type of Work, that may be applicable.

Insurances/Liability Coverages

Insurance coverages, limits and the parties to be protected via insurance riders, etc. are described elsewhere (i.e., in the Private Contract which contracts for this Work and within the requirements of the "State Permit to Work on State Lands" which must be obtained by Contractor from NYSOPRHP before work is initiated). No work shall be initiated until acceptable insurance certificates have been delivered to all the parties/organizations to be protected.

Period of the Contract

The Work is to commence as soon as possible after Private Contract execution with the various insurance certificates, permits, authorizations, etc. to be delivered to the named parties as soon as possible. The Work is to be completed no later than December 31, 1993.

C. Special Contract and Scope of Work Provisions

Limited Scope Reduction Available as Relief

No additional monies are available beyond the original commitment to Contractor as provided for in Private Contract. It is understood that Contractor has contracted to complete the Work, as specified, based upon material volumes as estimated by design engineer (Section A Above).

The basis of Contractor cost is strongly influenced by the volume of materials required to complete the contracted Scope and yet this is initially based on estimate. Because of the firm funding limit of the Project where no additional monies are available, a provision is provided in Private Contract and more fully described in this Section to provide relief should the eventuality arise where actual project material requirement exceeds the estimated volumes.

Control Authority

In the event of reported need, the engineering oversight entity, the NYSOPRHP, in concert with project sponsors and regulatory authorities, may choose to enact a procedure to allow a planned, limited and prioritized reduction in the Scope of the Work.

Contractor Responsible to Forecast, Report, and Request

The Contractor has the specific responsibility to order stone materials in a timely manner to meet his construction schedule. As part of this effort, Contractor shall monitor and log materials deliveries on a daily basis, keeping a record of all shipper lading tickets with explanation of material type noted. (Buffalo Crushed Stone, supplier of stone materials, may be requested to maintain a running tally for the same purposes.) These materials management records shall be available continually for the use of Contractor and perusal by NYSOPRHP Oversight Engineer.

Based on actual project conditions and the manner in which the Work proceeds, the Contractor has the primary responsibility to accurately forecast actual material requirements and to coordinate with the NYSOPRHP Engineer to adjust material needs to accomplish acceptable Work. These responsibilities are more specifically defined as follows:

Case 1. Actual Requirement Less than Estimate.

Should the actual material needs to complete the original Scope fall short of estimates, Contractor has the responsibility to reduce and/or stop materials deliveries in a timely manner, so as to eliminate the stockpile of material that would not otherwise be used in this Project.

Case 2. Actual Requirement Greater Than Estimate.

Should actual material needs to complete original Scope exceed the estimate, Contractor has responsibility to forecast the eventuality with enough lead time, and provide the necessary data, to allow the NYSOPRHP Oversight Engineer and other authorities to come to a decision regarding need for a Reduction in Scope action.

The Contractor has the following materials management responsibilities which must be followed to successfully obtain relief allowed through enactment of the Reduction in Scope provision:

- Collect and accrue all shipper slips on materials delivered (request shipper to keep running tally), provide data to NYSOPRHP regularly.
- Accurately relate tonnage of shipper slips to Yardage based on suppliers' backup for all material types. The conversion of 2.37 t/m^3 of NYSDOT Medium Stone shall be employed for the purpose of Medium Stone, unless other justification is provided.
- Closely Monitor use of placed materials at jobsite, make necessary measurements in order to regularly forecast material quantities needed to complete the Work as designed.
- Place orders for various materials with supplier to meet Contractor construction schedule; being careful not to over purchase.
- As Work proceeds, regularly report material management data and findings/projections to

NYSOPRHP Oversight Engineer;

- At the earliest possible opportunity, Contractor shall immediately report any shortfall of estimate or overage of estimate directly to NYSOPRHP Oversight Engineer to allow for consideration of the problem and assistance in resolution.

Reduction of Scope, Decision, and Agreement

Should a reduction in Project Scope be allowed, it shall be clearly defined in physical, descriptive terms, and written up as an addendum to this Scope. This Addendum shall not be in force, however, until such time as NYSOPRHP has obtained the mutual agreement of the project sponsors and regulatory agencies involved. The Addendum shall then be signatured by both parties to the agreement reached, i.e., NYSOPRHP and the Contractor.

Priority of Tasks

If a Reduction in Scope action is allowed, reduction in Work Task(s) shall only be considered with respect to the following elemental hierarchy. Reduction in Task Scope would be planned starting at the "lowest priority elements" of the Tasks in the following list and proceeding upward. It is not envisioned that any Task be eliminated, but rather that the amount of Work in one or another be marginally reduced as follows:

The highest priority work is assigned to the full completion of Task #1, the On-Shore Breakwater/Breach Repair, as designed and presented. It is most desirable to complete this work as designed.

The second highest priority would be to complete Task #3 which is the Outer Beach Strengthening Task, as designed and presented. A decrease in rip-rap stone breadth and depth, and thus total volume, may be considered.

The lowest priority would be Task #2, the Lagoon Beach Rip-Rap Task. Reductions in stone coverages may considered while still accomplishing the desired result.

D. Detailed Description of the Work

The following review of the major Work elements of Tasks #1, #2 and #3 is provided for general informational purposes only, and is to be used in combination with and for assistance in interpretation of the cited COE Nationwide Permit Design Drawing Sheets, No 1 through No 7. The review highlights major contract Work elements, including important Permit procedural requirements and serves to supplement project specifications.

This review may not be totally inclusive of all Work elements or sequences required. It is however intended that the Work, as described here and within the cited COE Permit, be complete in every respect, irrespective of the fact that some detail(s) may not appear in this description.

Detailed Work Elements, project responsibilities and necessary phases are all a part of this Scope of Work Review:

Mobilization and Demobilization Operations

- Project Oversight and Layout. A NYSOPRHP Engineer shall be present to act in a project oversight role to assist the contractor in answering technical questions, to oversight materials management practice and to assist in engineering layout and control of the work. Representatives of the COE and DEC may be present at the site at various times to insure compliance with the terms and conditions of the COE Nationwide Permit.

- Barge Loading at Wickwire Plant. Contractor shall be responsible to directly order, monitor and coordinate the deliveries of stone to the Wickwire Plant, or other agreed location, to meet his own construction schedule. (Stone materials purchased via standing Purchase Requisition by OTHERS). Contractor is responsible to load all necessary construction materials and equipment onto his barges for transport for off-loading at Strawberry Island. Contractor responsible to limit overages of stone materials delivered that may result in a stockpile that is objectionable to landowner and also wasteful of materials provided specifically for the Strawberry Island Project.

- Administration/Management of Materials Volumes as Relates to Project Scope. Contractor has specific materials management responsibilities in order to assist in the control of how the Work is completed. Special Condition Section C above outlines responsibilities that are to be followed.

- Dredge/Channel Operation, the minimum required, to move a shallow draft-crane barge (0.8-0.9 m draft) to a proximity close enough to the island for crane to reach and install the 36 m+/- long breach breakwater as depicted on Sheet no. 4 of 7 of COE Permit Drawings.

- Dredge/Channel Operation, the minimum amount required, in order to move deeper draft gravel barge (1.4-1.5 m draft loaded) into position parallel to but to the rear of crane barge, in order to supply Medium and Light stone materials to crane bucket.

- Machinery on the Beach. Contractor is responsible to choose appropriate land based equipment and machinery that is capable of efficiently and effectively performing the Work. Simultaneously, it is expected that its deployment and operation shall not cause undue damage to the fragile landmass, remaining vegetative cover, water quality or wildlife of the Island.

TASK #1

- Shallow Foundation Trench at Front and Rear Toe of Breakwater. Contractor shall layout and carefully excavate shallow trench which defines the front and rear toe line of breakwater walls. This excavation shall be minimal; existing clay banks and vegetated shoreline shall be protected as far as is practicable. This trench line shall be employed to strongly anchor the toe of the breakwater into the subsoils in river bottom or rear lagoon beach.

- Geotextile Installation. A high-tensile strength geotextile material (material provided by OTHERS), provided in standard widths on continuous rolls, shall be installed with a minimum 15 cm overlap, underneath the Medium and Light stone (core) breakwater being constructed. A 10 cm thick "cushion layer" of smaller granular materials, such as NYSDOT Spec Fine stone (2.5 cm diameter) shall be placed initially to hold the geotextile in place and to protect it from puncture from the larger stone to be placed. The geotextile shall continuously line the foundation trench at the front and rear toe of breakwater walls and run the full depth of breakwater being constructed, i.e., varying from approximately 12 m to 14 m overall, front to back.

Geotextile shall be carefully laid upon existing clay banks at the shoreline and attention given to its fit between existing "fingers" of eroded soils. Existing vegetation and irregular clay banks shall not be impacted by construction and protected as far as is practicable before coverage with geotextile and then stone.

Any materials and/or special methods or devices required to place the geotextile material in a neat and "workman-like" manner is the responsibility of the Contractor and is included in the Work.

- Materials Placement-Dredging Spoils. (Refer also to Section E for Dredging Guidelines of Permit) To the maximum degree possible, once the crane barge is in close proximity to land, the Contractor shall cast dredged materials being removed from river bottom to a stockpile position behind the (future) front stone breakwater wall being constructed for possible use as core materials. (Stockpile shall not be constructed directly on top of any existing vegetative cover. All existing cover shall be protected from further damage.) Once front and rear stone breakwaters are formed, Contractor shall place small stone and/or subject dredged stockpiled soils, in the core, up against the back walls of the new breakwater, smooth with the profile of new stone breakwater.

These dredged spoils materials placed in the core shall be employed by NYSOPRHP for the future establishment of vegetative cover in the core zone.

- Materials Recovery-Deposited Sands and Gravels behind Breach. To the extent possible, and understanding that it is more advisable to minimize the extent of channelling to allow barge movement toward the Island, the Contractor may consider the recovery of sands and gravels that have washed through the breach and are present at the lagoon just behind the present breach location. These "transported" materials would be available as an alternate core material.

- Materials Placement-Medium Stone of Breakwater. Layout of intended lines and grade of breakwater shall be established through consultation with NYSOPRHP On-Site Engineer. Contractor shall carefully begin placement of Fine and then Medium spec stone' onto geotextile foundation material so as not to damage foundation liner, nor allow it to become displaced due to river current.

Contractor shall place medium stone to the slopes and cross sections as depicted on sheet 4 of 7 of the COE Permit Drawing Sheets. The end transitions of the breakwater, as they approach the irregular land forms, shall be neatly contoured and securely benched into existing landforms so as to cause least disturbance to existing conditions of landmass and yet create end wall stability that will not be eroded. The overall top height of the new breakwater (at the 1.5 m top and 0.9 m top section) shall generally "match" the existing adjoining landform elevation, i.e., measure an approximate distance of 12 m to 15 m up each "arm" from the present breach shoreline and build top of wall "level" to the elevation present at these points.

The medium stone shall be laid to a well defined line and grade in a neat and workmanlike manner. The finished product shall be a low profile structure that has interstitial spaces packed as tightly as possible with the smaller grades of "medium" stone delivered. It is acknowledged that some amount of hand placement work may be necessary to obtain the desired "tight knit" composition of breakwater wall construction necessary to stand up to natural forces present at the site.

TASK #2

- Lagoon Beach Rip-Rap Placement. The Contractor shall place stone in the coverage zone as specified, immediately upon the sand/gravels of existing beach and shoreline with no initial grading or preparation. No vegetative cover upland of the beach shall be destroyed and it shall remain outside the influence of the Work. A line of heavier materials shall be placed at the lower elevation line of the zone, within the shallows, to form a foundation line to hold materials above. The final shape of this beachline stone shall be formed with smooth transition to the northeasterly corner, rear wall, of the on-shore/breach repair breakwater of Task #1.

Subject Stone shall be placed to cover the total exposed sand/gravel beach above the waterline, for the full distance of approximately 30 m, directly to vegetative cover. Additionally, stone shall be placed below the waterline, for the full distance, to a minimum distance of 3 m. This stone shall be laid a minimum of 30 cm thick in all areas; no geotextile shall be employed in Task #2.

TASK #3

- Outer Beach Strengthening. The Contractor shall place a mixed composition of specified materials within the coverage zones as depicted.

Approved geotextile material shall first be placed throughout the full "footprint zone" of the Work as depicted. Natural clay banks or vegetation shall not be trimmed, smoothed or otherwise damaged in order to place the fabric to the contours or irregularity of eroded shoreline. Bedding materials shall next be placed in a layer adequate to assist in the fitting of the fabric to the shoreline and to protect the fabric from puncture during placement of the larger stones. Geomaterial placement shall be accomplished in a neat and workmanlike manner with no loose ends and no fabric exposed to view.

Medium stone and Light stone shall be placed throughout the footprint zone as depicted for an approximate shoreline distance of approximately 27 m. Throughout this distance, stone shall fully cover the area from the waterline to points above, up to the irregular vegetative cover line, and also cover all area below the waterline to a line approximately 3.6 m from the waterline (parallel to shore).

The placed stones shall make a smooth transition with the top of existing clay banks at the vegetative line. Medium Stones shall be placed, at all locations, a minimum of 45 cm deep; Light spec stone shall be employed to fill all interstitial spaces within all placed Medium stone as far as is practicable in this beach strengthening Task.

Project Closure

- Cleanup/Demobilization. The Contractor shall leave the site, both on-shore and off-shore, in a neat and clean condition with no garbage, trash, abandoned equipment or materials present. Channel marker buoys or turning piles employed in the Work shall be completely removed.

This requirement is inclusive of excessive clean stone materials that may have been delivered and spoils piles of any sort, inclusive of deposits created by dredging operations in the river bottom.

Should spoils deposits be evident in river bottom at project end, they shall be removed and placed within the dredged channelway as the gravel barge and crane barge are moved out of position and into deeper water for exit.

Permit Conditions Focus Relates to Work Methods

After a review of COE Nationwide Permit conditions as relates to work in shallow, sensitive coastal waters and follow-up consultation with the issuing regulatory authorities, the following specific "Permit Conditions" are provided and to be considered Addendum to the Permit as originally written:

1. Dredging/Channelling Orientation to Island.

Contractors vessels shall approach the breach location from the north running into the current and channel towards shore in an easterly or southeasterly orientation, i.e., will not be allowed to approach and channel perpendicular to shoreline or in an orientation heading northerly (with the current). (Background Intent: Channels, when job is completed, shall be pointing in a generally downstream direction and away from the island shore.)

2. Dredged Materials Minimization, Casting and Stockpiling.

The volume of dredged materials shall be minimized through all means, methods and decisions available to the Contractor and oversight NYSOPRHP Engineer, while allowing the described Scope of Work to be accomplished.

The volume of dredged materials cast into the river shall be minimized through all means, methods and decisions available to the contractor and oversight engineer. All materials dredged that must to river shall be cast on the downriver side of barge.

When dredging first begins, contractor shall cast materials back into the deeper, swifter moving currents of the river, as far as possible, with the intent of distributing the dredged load throughout a large downriver settlement area.

As dredging proceeds and approaches land, contractor shall stockpile dredgings on the downriver side of barge in the shallows, with the intent of reusing a portion to refill the channel on exit of the barge. Care shall be exercised to not allow a scour current to be formed between any dredged stockpile and the island shoreline that could accelerate erosion of the shore in the area of the project.

Once the crane barge is close enough to the island, the contractor shall stockpile as much dredged materials as possible behind the future location of the front breakwater wall for usage as core materials between the front and rear stone walls. (Minimize volumes going into the river through this usage; also allows vegetation to be established here later.)

The use and placement of Sediment Curtains are not included in this Work.

3. Prevention of Severe Erosive Currents at Shore.

Through all the operations that are necessary for the Contractor to accomplish the Work, the Contractor must remain cognizant of the strong currents present and plan to avoid any negative erosive effects it could have, as amplified by any construction actions, at the shoreline during construction.

As examples of this concern, this Scope of Work has previously discussed the required orientation of channels in relation to the island and existing currents. Also. the requirement to prevent scour currents at the shoreline is discussed in 2. above. Any other unforeseen conditions or situations, that are preventable through proper work planning, that causes unnatural, severe erosive forces to be continuously applied to the present shoreline, and/or the work in process, are to be avoided.

4. Prevention of Damage to Existing Vegetative Cover, Landmass or Wildlife Habitat.

The Contractor shall exercise extreme caution and care in working on and around the Island to ensure that environmentally sensitive areas are not damaged in any way. All work procedures and operations are subject to the approval of the NYSOPRHP Oversight Engineer. Should any damage occur, the affected areas shall be restored immediately by the Contractor to his account in accordance with instructions of and to the satisfaction of the NYSOPRHP Oversight Engineer.

5. Filling Channel and Cleanup.

The channels that were dredged for the crane and gravel barge are not required to be totally backfilled with natural materials to a smooth river bottom grade as it is expected that materials naturally transported in the river will quickly settle out and slowly fill the subject channels.

However, no massive, discernable, cohesive materials deposits from the dredging operation will be allowed to remain in river bottom at the site. Any such materials that remain at the close of project shall be moved to a position behind the newly constructed breakwater (as beach strengthening) or used to backfill the subject channels.

End of Scope of Work
Strawberry Island Emergency Project
Edition Date: December 1, 1993.

Appendix 3

Strawberry Island Stabilization Project

Target

Strawberry Island shoals is the largest riverine littoral area in the Niagara River. The island is located roughly midstream ~ 2 km south of Grand Island. The area is managed by NYS Office of Parks-Western Division from adjacent Beaver Island State Park on Grand Island. In spring, 1993, erosive forces of ice/wave action and human activity had caused a 9 m wide breach in the island. The breached section was repaired by constructing a 46 m onshore breakwater in December.

Description

Problem/Need:

The onshore breakwater was designed and constructed, to the extent possible, to resemble pre-existing conditions. Inherent in the design is the revegetation of the area, using native and naturalized plantings, to prevent erosion. Planting is scheduled to take place May 2-3, 1994, in advance of the growing season and migratory bird nesting on the island.

Purpose/Goals

To stabilize the shore of Strawberry Island (notably the onshore breakwater and other threatened areas) using appropriate wetland and upland plant species. Goals, in descending order of priority, are to:

1. Strengthen construction and prevent erosion;
2. Restore wildlife habitat;
3. Discourage indiscriminate foot traffic; and,
4. Improve aesthetics.

Contacts

Ray Spencer, Conservation Educator Assistant
NYS Office of Parks - Schoellkopf Geological Museum
Tel.: (716) 278-1780; FAX (716) 278-1744

Ann Poole, Fish & Wildlife Biologist
USFWS - Lower Great Lakes Fishery Resources Office
Tel.: (716) 691-5456; FAX (716) 691-6154

John Whitney, District Conservationist
USDA - Soil Conservation Service, Erie County
Tel.: (716) 652-8480; FAX (716) 652-8506

Budget

Materials	*Cost*
Streamco willow (*Salix purpurea* 'Streamco'), 45-60 cm, bundled	n/c
Bankers willow (*Salix cottettii* "Bankers'), 45-60 cm, bundled	n/c
Deer tongue (*Dicanthelium clandestium*), 453 g, p.l. seed	n/c
Coastal panicgrass (*Panicum amarum* 'Atlantic'), 453 g, p.l. seed	n/c
Switchgrass (*Panicum vergatum* 'Shelter"), 453 g, p.l. seed	n/c
Redtop (*Augustus giantia*), 453 g, p.l. seed	15.00
American beachgrass (*Ammophila breviligulata* "Cape"), 300 plant units	n/c
Prairie cordgrass (*Spartina pectinata*), 100 plants	n/c
Highbush cranberry (*Viburnum trilobum*), 1.8-3 m, 10 @ $0.70 ea.	7.00
Redosier dogwood (*Cornus sericea*), 3.6-5.5 m, 10 @ $2.50 ea.	25.00
Nannyberry (*Viburnum lentago*), 1.8-3.6 m, 10 @ $2.50 ea	25.00
Buttonbush (*Cephalanthus occidentalis*), 15-30 cm, 10 @ $2.50 ea.	25.00
Shadbush (*Amelanchier aborea*), 1.8-3.6 m, 10 @ $2.50 ea.	25.00
Swamp rose (*Rosa palustris*), 15-30 cm, 10 @ $2.50 ea	25.00
250 - 5.5 m long 60 cm x 10 cm	n/c
1 - 608 m roll jute baling twine	50.00
23 kg. 10-10-10 fertilizer	50.00
227 kg. topsoil	100.00
3 bales straw mulch	n/c
3 shovels	n/c
2 crowbars	n/c
2 picks	n/c
2 mauls	n/c
6 hand trowels	n/c
10 pairs of work gloves	n/c
40 free-standing survey flags	n/c
Personnel	
8-10 people (employees of NYS Office of Parks, USDA-SCS, and USFWS-LGFRO), 2 days	n/c
Total cost	**$ 347.00**

Schedule

1. Order materials, as needed.	April 15
2. Receive materials, on or before	May 2
3. Project implementation	May 2-3

Planting Scheme

See Figure 8.

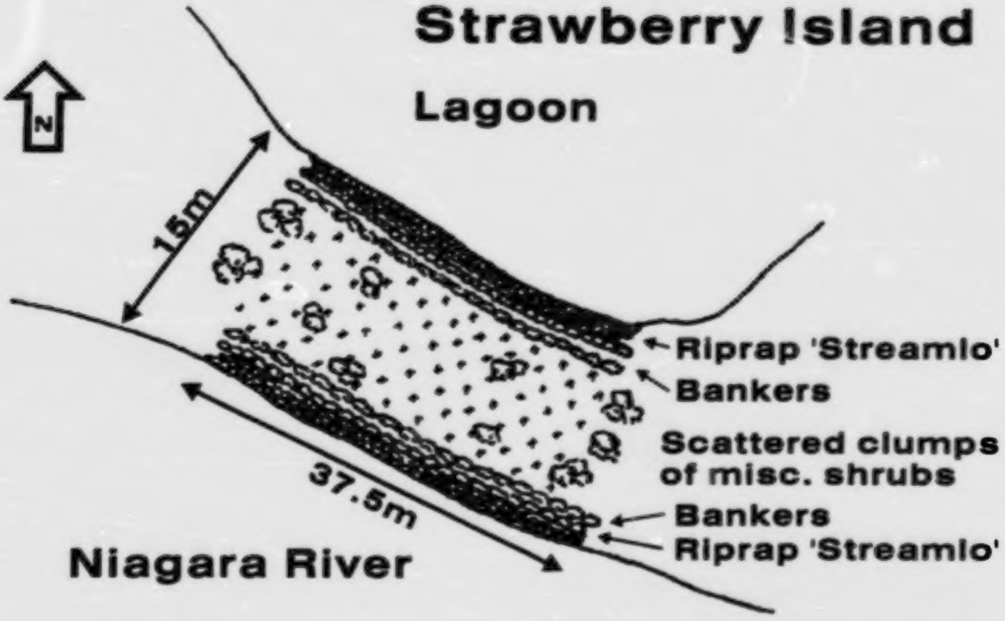
Strawberry Island
Lagoon
N
15m
37.5m
Riprap 'Streamlo'
Bankers
Scattered clumps of misc. shrubs
Bankers
Riprap 'Streamlo'
Niagara River

Figure 8.

Project 35

1. Project Title: Sand Creek Bank and Channel Restoration

2. Contact

Jim Dexter, Fisheries Management Biologist
621 North 10th street, P.O. Box 355, Plainwell, Michigan 49080
Tel.: (616) 685-6851; FAX: (616) 685-1362

3. Agencies Involved

Michigan Department of Natural Resources
Fisheries Division, P.O. Box 355, Plainwell, Michigan 49080

Michigan Wildlife Habitat Foundation
6425 S. Pennsylvania, Suite 9, Lansing, Michigan 48911

Kalamazoo Valley Chapter Trout Unlimited
Ed Hoover, 2595 5th Street, Shelbyville, Michigan 49344

4. Restoration Goal

Restore bank blowout from flood and restore original channel from blowout. Provide additional trout habitat and restore spawning areas.

5. Project Type

Channel restoration, trout habitat enhancement, and spawning habitat restoration.

6. Background and Rationale

Sand Creek is a small, third order tributary to the Kalamazoo River (Allegan County) in southwest Michigan. The average stream discharge is approximately 0.14 m^3/s. The creek averages 2.7 m wide and is about 10 cm deep. It has a fall of over 48 m from its headwaters to confluence in just under 9.6 km. Natural populations of brook and brown trout reside in the creek, along with spawning populations and recruitment of chinook salmon, coho salmon, and rainbow trout.

In 1978, a 30 cm rainfall event caused the creek to "breach" the bank and eliminate perhaps the most significant spawning reach in the entire creek. This 90 m reach of channel was in the shape of an oxbow. In 1985, funding was supplied by the Michigan Wildlife Habitat Foundation to the Michigan Department of Natural Resources Fisheries Division to correct the breach by rebuilding the bank to direct the waterflow back into the original stream channel and add some additional habitat for trout and salmon through the addition of rocks and logs. The de-watering of the original stream channel caused the loss of the largest suitable area of spawning gravel for trout and salmon.

7. Regulatory Considerations

(A): Completion of application for permit under the Michigan Inland Lakes and Streams Act, 1972 P.A. 346, as amended.

8. Criteria

Stabilization of banks to prevent erosion of sediments, addition of habitat (rocks/logs/stumps) to provide cover, sites for production. The area of channel that was lost due to the breach contained some of the best available habitat in the creek for production and nursery areas for trout and salmon. In addition, the flood swept away much of the available habitat in that section. Our criterion (or goal) was to restore the original channel in such a way as to include installation of suitable habitat and preservation of gradient to keep gravel beds clean of sediment.

9. Project Design

The project was designed only to restore the old channel by blocking the new channel, and adding habitat to the creek that was washed out with the flood. At the same time, the channel sides would be rip rapped for further protection from future high water levels. These steps would ensure that the high quality spawning areas would remain useful to salmonids.

10. Implementation

Problem developed in 1978. Funding requested each year through 1985 from the State, but never funded. Outside funding sought in 1985 and approved by Michigan Wildlife Habitat Foundation. Act 346 permit approved in June 1986. Construction and completion of the project was accomplished in 2 weeks in August of 1986. Construction was completed by a combination of Michigan Youth Corp workers, Michigan Department of Natural Resources Fisheries Division personnel, and by contract with a private excavator.

Construction involved clearing an access road through a State forest (approximate length of 0.8 km), getting an excavator down to the creek and cleaning and reshaping the damaged channel back to its original shape. Bank stabilization was done on three areas of this channel where erosion had occurred. This work was done with tree stumps, logs, and rock (field stone). Large rocks were placed in the channel to enhance food production and provide cover for trout. A narrow "plug" of land was left between the existing and new channels so that rocks, a pool, and rock riprap could be placed in the channel while dry. A berm was also constructed to assure the stream was directed to the proper location. Finally, the original channel was opened and another berm was constructed to divert the stream from the new channel to the original channel. The berms were constructed with soil, filter fabric, and rock. Upon completion of the work, the access road was closed off with 3 berms, posts and the road and work area were seeded with a plant mix which provided food for wildlife cover as well (Figure 1).

By August 1991, some slumping of rock rip-rap occurred and small erosion areas developed on the construction berm. Funding for repairs were once again provided by the Michigan Wildlife Habitat Foundation, with work being directed by the Michigan Department of Natural Resources Fisheries Division, and work being accomplished by the Kalamazoo Valley Chapter Trout Unlimited.

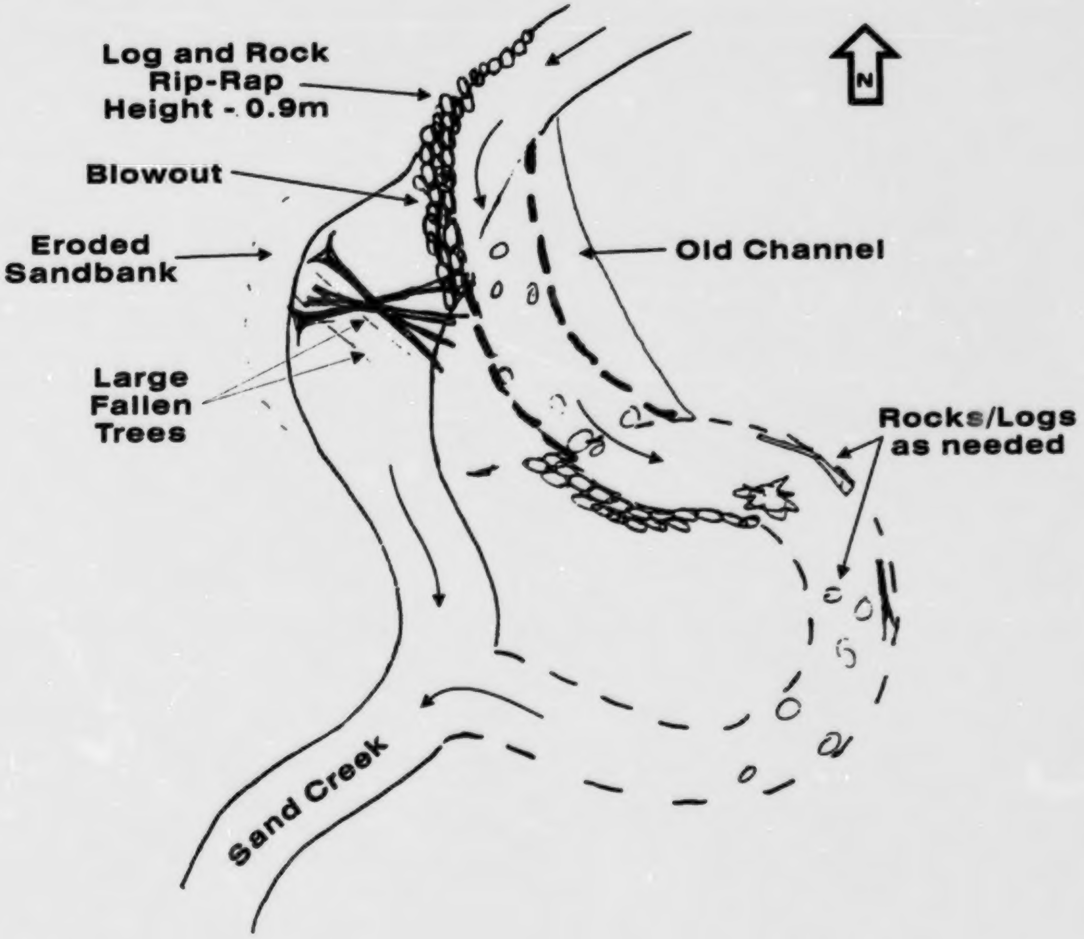
Log and Rock
Rip-Rap
Height - 0.9m
Blowout
Eroded
Sandbank
Large
Fallen
Trees
Old Channel
N
Rocks/Logs
as needed
Sand Creek

Figure 1.

11. Degree of Environmental Intervention

Most of the work was conducted by excavator and by hand. Some rocks and logs had to be individually placed. All material used was local. Stumps and logs were cut or gathered from the State Forest which the creek flows through. Field stone was delivered from a local quarry. Only short-term intervention was required since the majority of the channel work was done in the dry. Completing this project required the dewatering of a relatively short stretch of creek (less than 60 m) and subsequent loss of any production this area established since its "creation" in 1978. However, additional stream footage was regained upon completion of the project, and successful salmonid reproduction occurred in the reclaimed stretch in the fall of 1986.

12. Cost

Engineering/design (by field biologists):	$500
Construction costs:	$6 850
Supervision	$1 000
Subtotal	$8 350
Assessment costs:	
Field crew for population samples:	
2 Technicians, 1 Biologist (2 days)	$450
1 Biologist for data workup (1 day)	$150
Total estimated costs	**$8 950**

13. Biological Assessment

Mark and recapture population estimates were conducted in August of 1991. A 12 Volt D.C. backpack electroshocker was used to evaluate a stretch of approximately 300 m of creek, which had this improvement area right in the middle of the stretch. In addition, 2 other areas of the creek were sampled, one area each below and above the area that was worked on. Our mark and recapture estimates showed that the project was successful, as naturally produced salmonids were found in good abundance at the project site location:
Rainbow trout: Estimated 1728 fish/ha (16 kg/ha); size 2.5-17.5 cm
Brook trout: Estimated 212 fish/ha (7 kg/ha); size 5-22.5 cm
Coho salmon: No estimate but 7 parr (7.5-10 cm) were collected.

14. Measures of Success

Our measures of success were as simple as (1) are salmonids utilizing the project site, (2) are salmonids successfully spawning, and (3) are the stabilizations that occurred holding up over time? Numbers 1 and 2 were met, as was number 3 at least partially. While most of the stabilizations that occurred have held up over time and through several large rain events, some slumping did occur and maintenance had to take place in order to preserve the integrity of the entire stabilization. Future monitoring of the site will occur in order to follow the progress of the brook trout population (the key species we are managing for) which appears to be at a low level.

Success Rating: 5

15. Key References

None.

Correct citation for this contribution:

Dexter, J. 1995. Sand Creek bank and channel restoration, p. 231–235. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 36

1. **Project Title: Early Life History of Northern Pike in Artificial Wetlands of Conesus Lake, New York**

2. **Contact**

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3. **Agencies Involved**

U.S. Army Corps of Engineers,
Waterways Experiment Station

4. **Restoration Goal**

This study was a biological assessment of four artificial wetlands. We were not involved in initial construction of the wetlands. Purpose of the wetlands was to increase spawning habitat for northern pike.

5. **Project Type**

This project was an evaluation of the attempted increase in northern pike spawning habitat.

6. **Background and Rationale**

Wetlands were constructed in 1990 and 1991. Data was collected for evaluation in 1992, 1993, and 1994. The wetlands were constructed as mitigation for a flood control project. Our study was part of the U.S. Army Corps of Engineers wetland research project.

7. **Regulatory Considerations**

Collection permits were required for the evaluation. Wetland regulations may apply where dike or dam construction is required.

8. **Criteria**

Must have low lying areas adjacent to inlet streams for construction of this type of wetland to be feasible.

9. Project Design

Four wetlands were constructed adjacent to Conesus Inlet Creek by lowering ground levels below normal spring high water levels.

10. Implementation

Wetlands were constructed in 1990 and 1991. Vegetation had to be established before the wetlands could operate as viable spawning habitat; thus, one growing season was required between the end of construction and viable operation.

11. Degree of Environmental Intervention

A project of this type requires a bulldozer or other heavy earth moving equipment. No foreign materials are necessary, but high quality clay for construction of dikes may be desirable. Removal of trees may impact species that rely on forested habitats.

12. Cost

This evaluation did not consider cost of the project.
Cost would vary greatly depending on site characteristics.

13. Biological Assessment

This study was the assessment for the initial project. Reproductive success of northern pike as measured by numbers of pike larvae produced was the only variable examined.

14. Measures of Success

As measured by production of larval northern pike, the project was successful in the short term. Problems with maintaining the wetlands are discussed briefly in the report. Long-term evaluation of the Conesus Lake northern pike fishery will be necessary to determine if more northern pike are being recruited into the population.

Success Rating (short term): 4

15. Key References

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Forney, J.L. 1968. Young northern pike in a regulated marsh. NY Fish Game J. 15:143-154.

Franklin, D.R., and Smith, L.L. 1963. Early life history of the northern pike *Esox lucius* L., with special reference to the factors influencing the numerical strength of year classes. Trans. Amer. Fish. Soc. 92:91-110.

Hunt, B.P., and Carbine, W.F. 1951. Food of young pike, *Esox lucius* L. and associated fishes in Peterson's ditches Houghton Lake Michigan. Trans. Amer. Fish. Soc. 80:67-83.

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Wright, R.M., and Giles, N. 1987. The survival, growth and diet of pike fry, *Esox lucius* L., stocked at different densities in experimental ponds. J. Fish Biol. 30:617-629.

Correct citation for this contribution:

Morrow, J.V. 1995. Early life history of northern pike in artificial wetlands of Conesus Lake, New York, p. 236–238. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 37

1. Project Title: Wayne County Detroit Metropolitan Airport Crosswinds Marsh Wetland Mitigation Project

2. Contact

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Dr. Donald L. Tilton
Johnson, Johnson, & Roy Inc., 110 Miller, Ann Arbor, MI 48104
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3. Agencies Involved

Michigan Department of Natural Resources (DNR)
Land and Water Management Division and Wildlife Division, Lansing, Michigan
U.S. Environmental Protection Agency (EPA), Chicago, IL
U.S. Fish and Wildlife Service, East Lansing, MI

4. Restoration Goal

To reestablish wetland values and functions lost due to airport expansion by restoring and creating wetlands. Wetland habitat to be restore and created include submergent, emergent, scrub-shrub, and forested areas. Primary wetland functions and values that were to be created were fish and wildlife habitat, water quality improvement, flood storage, and passive recreation.

5. Project Type

Restoration of wetlands that were drained for agriculture and creation of new wetlands from upland habitat.

6. Background and Rationale

The expansion of the Wayne County Detroit Metropolitan Airport required that certain wetland areas on the airfield be filled. As a condition of the permit, regulatory agencies required 189 ha of new wetland to be created. The wetland mitigation project has been completed on 326 ha of land allowing for more than adequate upland areas to be integrated into the overall mitigation complex.

7. Regulatory Considerations

An environmental impact statement was prepared for the expansion of the airport. State and federal wetland permits were obtained from the Michigan DNR and the U.S. Army Corps of Engineers with consultation of U.S. EPA and U.S. Fish and Wildlife Service. State threatened and endangered species permit from the Michigan DNR for relocation of plant species. County drain permit for relocation of county drain.

8. Criteria

Vegetation

Implement a revegetation program which will complement the local gene pool, increase plant diversity and control invasive species.

Preserve existing habitats and create new habitats for endangered, threatened and species of special concern.

Fish and Wildlife

Provide a variety of interspersed habitats for water fowl identified in the Lower Great Lakes/St. Lawrence Basin Joint Venture of the North American Waterfowl Management Plan.

Provide a variety of interspersed habitats for other birds, mammals, fish and other wildlife.

Develop a long-term wildlife management plan for the site.

Establish a warm water fishery with public access.

Water Quality

Develop a system of shallow water wetlands to remove pollutants from surface water entering the site. minimize impacts of upstream water quality, and maximize the water quality of discharge from the mitigation wetland.

Flood Control

Utilize state-of-the-art hydrologic and hydraulic computer modelling programs to provide stormwater storage through the use of passive low-maintenance detention structures.

Education and Research

Utilize the mitigation site for research on wetland restoration, creation. and management techniques.

Develop a resource for environmental education and interpretation for local schools.

Recreation

Develop a plan to identify recreational needs in the community which can be integrated into the mitigation program.

9. Project Design

The project was designed to meet the criteria established for the project in a cost effective manner. We attempted to create wetland habitat that was present on the property prior to European settlement of the area. We have added sufficient land to the project as a buffer against adjacent land uses. We have also attempted to relocate several threatened species of plants from the airfield to the mitigation area.

10. Implementation

Construction began in 1993. The design water level at the spillway was reached in March 1994. Plantings of all wetland types was completed in June 1994. Hydrologic calculations were essential to understanding the annual water level fluctuations in the wetland and to protect upstream property owners from flooding.

11. Degree of Environmental Intervention

Local drainage patterns were altered to create the wetland hydrology for the project. Local topography was altered to create the deep water habitat. but a large area of the project had no earth disturbance.

12. Cost

Construction cost was approximately $4.2 million.

13. Biological Assessment

The project was permitted after an Environmental Impact Statement (EIS) was prepared for the airport expansion. The EIS identified the alternatives to the proposed action and mitigation efforts that would be undertaken to minimize adverse impacts.

14. Measures of Success

The first year of a five-year monitoring program indicates that the hydrologic setting is successful and initial indications of plant community establishment are positive.

Success Rating (early results): 4

15. Key References

None.

Correct citation for this contribution:

Braun, R., and Tilton, D. 1995. Wayne county Detroit metropolitan airport crosswinds marsh wetland mitigation project, p. 239–242. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 38

1. **Project Title: Artificial Reefs in Lake Erie: A Habitat Enhancement Tool**

2. **Contact**

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Tel.: (614) 292-8949; FAX: (614) 292-4364; Internet: REUTTER.1@OSU.EDU

3. **Agencies Involved**

The Ohio State University Sea Grant College Program,
1314 Kinnear Road, Columbus, Oh 43212-1194, USA
The Ohio Department of Natural Resources,
Division of Wildlife, Building G – Fountain Square, Columbus, Ohio 43224
U.S. Army Corps of Engineers,
Buffalo District, 1776 Niagara Street, Buffalo, New York 14207

4. **Restoration Goal**

Enhance fish habitat in nearshore area.

Provide fish concentration sites for anglers and SCUBA divers.

5. **Project Type**

Construction of underwater artificial reefs using man-made materials (scrap concrete) strategically placed in nearshore areas.

6. **Background and Rationale**

Lake Erie is well known for its sport fishing. The shallow Western Basin, containing numerous islands, shoals and reefs, provide for excellent angling. The Central Basin is also a productive fishery, yet most effort is concentrated far offshore. Although deep water exists in close proximity to the shore, the rocky bottom is relatively flat and featureless. During 1982, in an effort to improve Central Basin angling and image, the North Central Sea Grant Extension Advisory Committee suggested the concept of artificial reefs. These structures were to be constructed of clean concrete, rock or brick, close to ports of shelter, so to create safe, productive fish concentration areas for small boat anglers.

We selected two locations to create demonstration artificial reefs. The Lorain site was located 1852 m west of Lorain Harbor and 1.2 km offshore. The Cleveland site was located 4,260 m west of Cleveland harbor, and 0.8 km offshore. These sites were selected due to close proximity to access and shelter and in depths that would appeal to a variety of fish species.

7. Regulatory Considerations

- Construction permit issued by U.S. Army Corps of Engineers.
- Compliance with Ohio Environmental Protection Agency (EPA) water quality standards/ EPA project approval.
- Project approval by United States Coast Guard (Navigation obstruction).
- Cooperation and approval by Ohio Department of Natural Resources/Division of Wildlife.
- Permits from Department of Natural Resources if required (bottomlands permit).
- Project approval by U.S. Fish and Wildlife Service.
- Permits to place navigation aids (marker buoys) from U.S. Coast Guard.
- Cooperation with Great Lakes Shipping Industry: Keeping clear of shipping routes.

8. Criteria

It is important to pre-determine the purpose for the reef and construct accordingly. Sport angling, recreational diving or fish spawning are examples of use. These demonstration projects were targeted specifically for sport angling usage. Other important criteria to assess prior to site location and construction include:

- target fish species
- bottom substrate hardness (penetrometer test) and composition
- angler access and distance from port of shelter
- water quality
- seasonal dissolved oxygen (Hypolimnion) and thermocline location
- water depth above substrate (safe navigation)
- commercial conflicts; other recreational conflicts
- potential ice scour damage
- waves and currents
- sediment plumes
- adjacent shoreline property owners and potential
- economic development and tourism opportunities
- possible erosion or deposition effects
- present use of site

9. Project Design

Our goal was to create fish habitat, conducive to fish species of angler importance, within the site locations. Ideally, we planned to develop habitat similar to natural reefs in western Lake Erie (Herdendorf and Braidech 1972).

As this project was dependent upon donations of dollars, materials and facilities from the private sector, we modified our plans to fit our budget.

During artificial reef construction, we attempted to create high profile substrate, while providing maximum substrate surface area for habitat enhancement and fish concentration.

10. Implementation

We began our efforts in 1984 with a small test project. Approximately 2 721 t of donated sandstone rubble was placed in 12 m of water at the Cleveland site. Reef material was placed in six separate, unconnected piles using a six compartment dump scow barge. Post project investigations revealed that the dump scow method scattered material resulting in reduced substrate height, which was only 1–1.5 m.

A 2-year research effort conducted during 1985-86 (Gerber 1987) and further literature review (D'Itri 1985; Mathews 1981) confirmed our structures needed to be larger, profiled, connected and in shallower water.

We began our demonstration projects in 1986 at the Lorain site with the placement of 1 814+ t of donated concrete rubble in 9 m of depth. Materials were placed using a barge/crane operation; providing more exact material placement and control of substrate height. Materials were placed in one long, irregular shaped line, parallel to the shoreline, with the height of piles ranging from 2 to 4.5 m. Piles of material were placed side by side, in a connecting manner, to form the reef 'chain'.

During 1987, over 3 447 t of donated concrete rubble was placed, using the same method described above at the Cleveland site, again, in 9 m of water. This formed an artificial reef approximately 243 m in length, with widths varying from 6 to 12 m, and height of material piles from 2 to 4 m. This exhausted our funding for Cleveland.

We returned to Lorain in 1988, placing an additional 2 268+ t of donated concrete rubble, in the above described method, to the existing reef structure. This created one reef with an approximate length of 450 m, widths varying from 6 to 12 m and profiles (height) of 2-5 m.

During 1989, we exhausted our funds for the Lorain site by placing 2 268+ t of donated concrete rubble. This material was placed approximately 90 m north of and parallel to the existing reef structure, so that more fish habitat 'area' would result. This resulted in a new reef structure approximately 167 m in length, with similar widths and heights.

Donated concrete, brick and stone rubble was utilized at both sites. Material sources were from highway and bridge projects, sidewalks, driveways and buildings, providing for a diversity of sizes and shapes. All materials were free of asphalt, oils and attached non-concrete building products. Rebar stabilizing rods were cut off to a maximum length of 30 cm to reduce angler gear and anchor fouling and SCUBA diver injury.

Scheduled days and times for materials donation, in addition to volunteers checking materials, prevented unwanted or contaminated materials at collection sites. These waterfront dockage 'material collection sites' were donated at both locations by private industry; providing a substantial cost savings.

The use of barge/crane operators appears to be essential for exact placement of materials. This was the only phase of the project that had a cost involved. It is imperative to have displacement calculations conducted on each barge to insure both amount of material placed and accurate costs per load of material placed.

Full-time supervision of the contractor is also essential to insure proper placement, adequate profiles of materials, and compliance with permit regulations/restrictions.

11. Degree of Environmental Intervention

No negative environmental impacts were expected or observed for this project. No modification of existing bottom substrates occurred prior to reef material placement. No negative biological or social impacts have been noted since project completion.

12. Cost

Unfortunately, exact costs for this project are difficult to determine due to donation of material, dollars, services and labor. Funding donations exceeded $100 000, the majority of which was used to pay marine contractors for materials placement. Cost of placement per tonne varied from $6.15 – $13.23 per tonne, (based on 1984–89 costs) depending upon the contractor. Small, non-union contractors fees averaged $8.27/t, making this option attractive.

Dockage and materials collections sites were donated, as was materials and material transport to the collection sites. Materials were not difficult to obtain; this project was highly publicized and had a high level of public acceptance. Also, most contractors needed a place to dispose of concrete scrap and rubble materials.

Much of the project supervision, fund raising and donation procurement and materials site inspection was conducted by volunteers from the North Central Sea Grant Advisory Committee, further reducing project costs.

Overall project supervision and monitoring was the responsibility of the Sea Grant District Specialist. As this effort was included in his job description, no direct costs to the project were realized.

We recommend the involvement of local private interest groups (fishing clubs, charterboat associations, environmental groups) to assist in fund raising and securing donations for materials and services. As projects of this nature can be highly visible in the community, and of great interest to specific organizations, securing donations and volunteer services can result in a very high benefit: cost ratio.

13. Biological Assessment

Anecdotal angler reports from both artificial reef sites (1987 – present) indicate high angler use, success and acceptance. SCUBA diver use, since water clarity improvements (due primarily to the zebra mussel) has also become a popular recreational activity at the reef sites.

Formal evaluation began during 1992 with two research efforts; one to determine fish concentration ability and the other to identify social and economic values.

During 1992 and 1993, underwater VHS video assessment was conducted monthly at the Lorain Artificial Reef site (Kelch and Snyder 1994; Snyder et al. 1994; Kelch and Snyder 1995). Dives were conducted monthly (May–October) at both the reef site and a non-reef control site to identify and enumerate fish and determine habitat differences. Total seasonal numbers of fish were significantly higher (*t*-test: p=0.01) at the reef site than at the control site for both 1992 and 1993. Total fish numbers were also significantly higher in spring and fall than mid-summer, suggesting seasonal patterns for preference of artificial structure.

During 1992, names and addresses of anglers were randomly collected at various launch sites and marinas for an economic and social research evaluation of the Lorain County artificial reef (Glenn et al. 1994). Surveys were mailed to 850 individuals during 1993, with 466 completed surveys returned (55% response rate). Respondents were asked numerous questions regarding recreational use and expenses on Lorain County waters; including questions specific to the artificial reef. 87% of the respondents indicated they knew about the reef, while 64% of these individuals indicated using the reef during 1992. The respondents indicated they like the reef because it was A) close to shore, B) the catch was good, and C) it was a marked location. The typical respondent made 20 trips to Lorain County waters during 1992, of which 7.1 trips (36%) included going to the reef to fish for part of the trip. The reef accounted for the largest percentage of smallmouth bass harvest (13%) and catch-release (30%) by respondents. However, the walleye was the species targeted on the reef (78%) and harvested on the reef (39%) by the largest number of respondents. (Economic benefits forthcoming – 1995).

14. Measures of Success

The Lake Erie Artificial Reef Program has been an extremely successful project. The project has been highly visible and has generated much enthusiasm within the sport fishing community. The project was cost efficient, and has helped improve the image of Lake Erie's Central Basin.

Underwater VHS video research has indicated the reefs to be effective fish concentration devices (Cleveland's artificial reef is currently being assessed using the VHS video technique; preliminary results rival those found at Lorain). Social and economic investigation has revealed excellent angler use and success.

The ultimate measure of success will be the application of our knowledge in the construction of future artificial reefs.

Success Rating: 5+

15. Key References

D'Itri, F. [*editor*]. 1985. Artificial reefs - marine and freshwater applications. Lewis Publishers, Inc., Chelsea, MI. 581pp.

Gerber, J.M. 1987. Fish use of artificial reefs in the Central Basin of Lake Erie. Masters thesis, The Ohio State University, Columbus, OH.

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Kelch, D.O., Snyder, F.L, and Reutter, J.M. 1995. Artificial reefs in Lake Erie: an evaluation of their effectiveness as a fish concentrating device. Conference Proceedings, 35th Ohio Fish and Wildlife Conference, February 17, 1995, Columbus, OH.

Mathews, H. 1981. Artificial Reef Site Selection and Evaluation. In Artificial Reefs: Conference proceedings. Univ. Florida Gainesville, FL. Florida Sea Grant College Program Report 41: 50-54.

Snyder, F.L., Kelch, D.O., and Reutter, J.M. Effectiveness of an artificial reef as a Lake Erie fish attractor. Conference Proceedings, 56th Midwest Fish and Wildlife Conference, December 7, 1994. Indianapolis, Indiana.

Additional Non-Cited Reference

Seaman, W., Jr., and Sprague, L.M. [*editors*]. 1991. Artificial habitats for marine and freshwater fisheries. Academic Press, Inc., San Diego, CA 92101. 285pp.

Correct citation for this contribution:

Kelch, D.O., and Reutter, J. 1995. Artificial Reefs in Lake Erie: A habitat enhancement tool, p. 243–249. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 39

1. Project Title: Burns Harbor Major Rehabilitation – Submerged Breakwater Reefs

2. Contact

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3. Agencies Involved

Chicago District Corps of Engineers
Burns Harbor Port Authority
Indiana Department of Natural Resources (IDNR)
Illinois Natural History Survey (INHS)

4. Restoration Goal

To increase the amount of spawning area available for lake trout which are known to spawn in the immediate vicinity.

5. Project Type

Breakwater improvement – to reduce the wave energy and increase navigation safety.

6. Background and Rationale

The submerged reefs will be located 22.8 m north (toe-to-toe) of the existing breakwater at Burns Harbor, Portage, Indiana (Figure 1). The primary purpose of the project was to reduce damages to shipping and maintenance costs by attenuating wave energy associated with waves greater than 5 m in height before they strike the existing breakwater.

The submerged reefs will be composed of large armor stone which will provide incidental fish habitat. The bedding stone, which separates the heavy armor stone from the underlying sand, will extend 3 m from the base of the reef. The size of the bedding stone was modified from the original proposal to provide better spawning substrate for lake trout.

7. Regulatory Considerations

The Chicago District Corps prepared an Environmental Assessment including a section 404(b)(1)

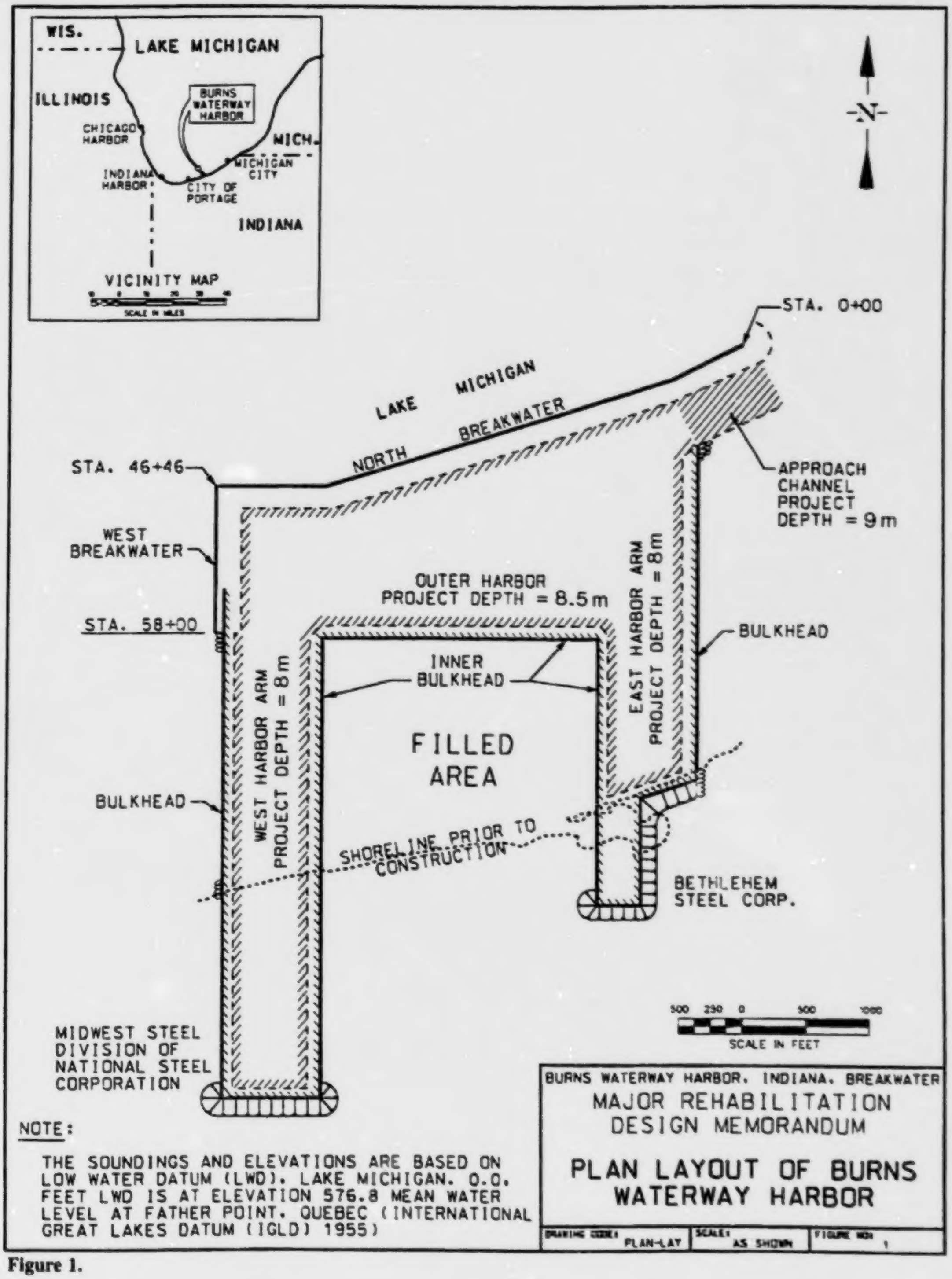

WIS.
LAKE MICHIGAN
ILLINOIS
BURNS WATERWAY HARBOR
CHICAGO HARBOR
MICH.
MICHIGAN CITY
INDIANA HARBOR
CITY OF PORTAGE
INDIANA
VICINITY MAP
SCALE IN MILES
N
STA. 0+00
LAKE MICHIGAN
NORTH BREAKWATER
STA. 46+46
APPROACH CHANNEL PROJECT DEPTH = 9 m
WEST BREAKWATER
OUTER HARBOR PROJECT DEPTH = 8.5 m
EAST HARBOR ARM PROJECT DEPTH = 8 m
STA. 58+00
BULKHEAD
INNER BULKHEAD
WEST HARBOR ARM PROJECT DEPTH = 8 m
FILLED AREA
BULKHEAD
SHORELINE PRIOR TO CONSTRUCTION
BETHLEHEM STEEL CORP.
500 250 0 500 1000
SCALE IN FEET
MIDWEST STEEL DIVISION OF NATIONAL STEEL CORPORATION
NOTE:
THE SOUNDINGS AND ELEVATIONS ARE BASED ON LOW WATER DATUM (LWD), LAKE MICHIGAN. 0.0. FEET LWD IS AT ELEVATION 576.8 MEAN WATER LEVEL AT FATHER POINT, QUEBEC (INTERNATIONAL GREAT LAKES DATUM (IGLD) 1955)
BURNS WATERWAY HARBOR, INDIANA, BREAKWATER
MAJOR REHABILITATION DESIGN MEMORANDUM
PLAN LAYOUT OF BURNS WATERWAY HARBOR
DRAWING CODE: PLAN-LAY
SCALE: AS SHOWN
FIGURE NO: 1

Figure 1.

water quality evaluation and we obtained section 401 certification from the IDNR.

8. Criteria

To benefit the lake trout we specified a bedding stone size of 10 – 25 cm. There was little leeway allowed in the depth of the bedding stone layer or in the distance it extends from the base of the reef.

9. Project Design

The project will place seven submerged breakwater segments 22.8 m (toe-to-toe) from the existing breakwater. The reefs will be placed in 13.7 – 15.2 m of water, with a top crest 6.1 m below low water depth (LWD). Six of the oval segments will be 114.3 m long by 45.7 m wide. The segments will be 7.6 m apart at each end. A larger single segment will be approximately 480 m long by 45.7 m wide. The bedding stone will be 0.45 – 45 kg, 0.06 – 0.30 m, the interior stone will be 45-907 kg, 0.30 – 0.81 m and the armor stone will be 0.907 – 4.54 tonnes, 0.81 – 1.38 m (Figures 2 and 3).

10. Implementation

The reefs will be constructed over a 3 year period from June 1995 to September 1997. The

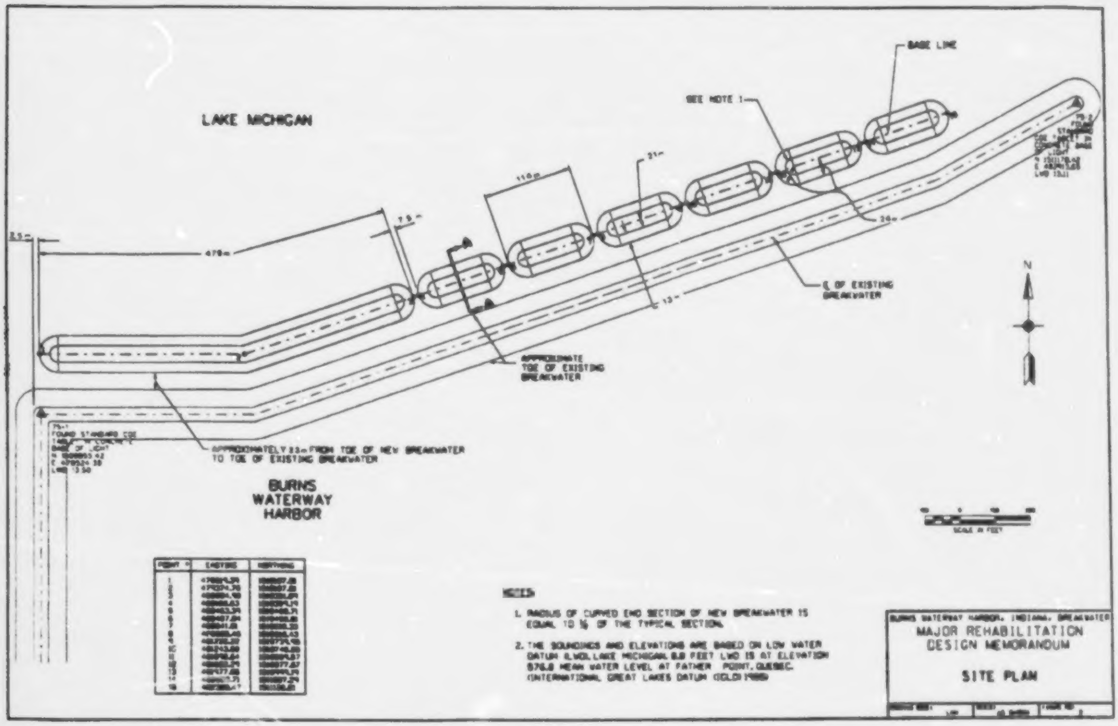

LAKE MICHIGAN
BASE LINE
SEE NOTE 1
21m
110m
7.5m
2.5m
479m
24m
13m
℄ OF EXISTING BREAKWATER
APPROXIMATE TOE OF EXISTING BREAKWATER
APPROXIMATELY 23m FROM TOE OF NEW BREAKWATER TO TOE OF EXISTING BREAKWATER
N
BURNS WATERWAY HARBOR
SCALE IN FEET
NOTES:
1. RADIUS OF CURVED END SECTION OF NEW BREAKWATER IS EQUAL TO ½ OF THE TYPICAL SECTION.
2. THE SOUNDINGS AND ELEVATIONS ARE BASED ON LOW WATER DATUM (LWD) LAKE MICHIGAN. 0.0 FEET LWD IS AT ELEVATION 576.8 MEAN WATER LEVEL AT FATHER POINT, QUEBEC. (INTERNATIONAL GREAT LAKES DATUM (IGLD) 1985)
BURNS WATERWAY HARBOR, INDIANA, BREAKWATER
MAJOR REHABILITATION DESIGN MEMORANDUM
SITE PLAN

Figure 2.

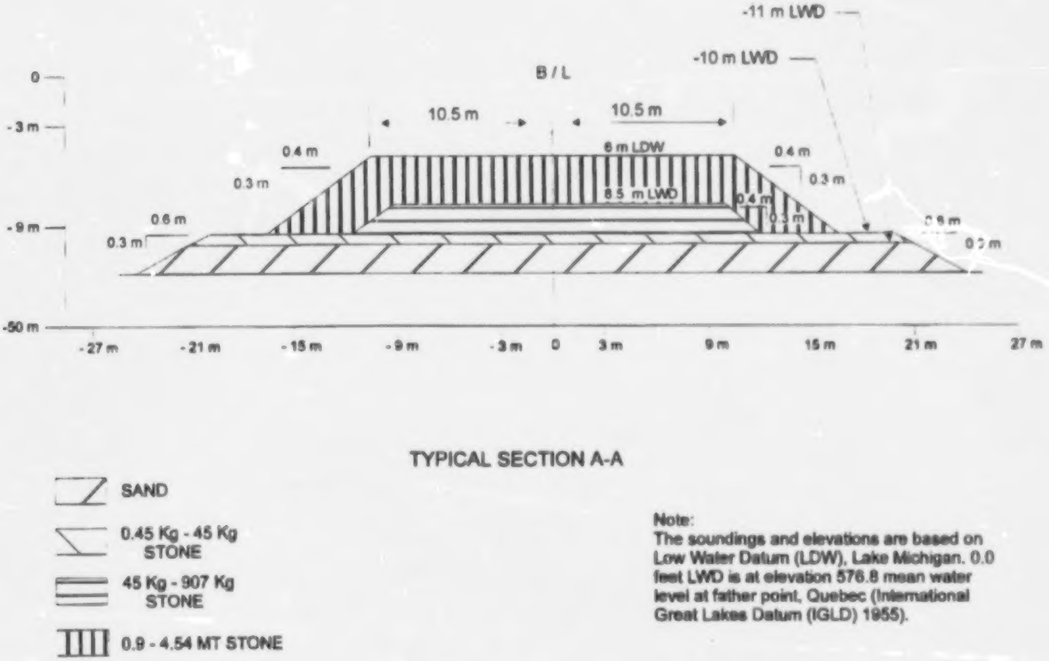
project will be located at Burns Harbor, Indiana. The project was undertaken to protect shipping. The submerged reefs were the best, most cost-effective means of supplanting the existing breakwater and protecting the harbor from wave impacts. The normal work season extends from April to November; a work window was imposed on this project to prevent disturbance to spawning and hatching lake trout. Work will be permitted between 1 June and 15 October.

11. Degree of Environmental Intervention

Highly interventive project. Requires heavy equipment, barges, cranes for open lake construction. Use of quarried limestone for reef construction. Turbidity may be an adverse impact. Deep water placement of materials may prove troublesome with small diameter stone.

12. Cost

Estimated construction costs are about $14 million (US). Assessment and monitoring estimated to be $8 000 annually.


-11 m LWD
-10 m LWD
B / L
10.5 m
10.5 m
6 m LDW
8.5 m LWD
0.4 m
0.3 m
0.6 m
0.3 m
0.4 m
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0.4 m
0.3 m
0.6 m
0.3 m
0
-3 m
-9 m
-50 m
-27 m
-21 m
-15 m
-9 m
-3 m
0
3 m
9 m
15 m
21 m
27 m
TYPICAL SECTION A-A
SAND
0.45 Kg - 45 Kg STONE
45 Kg - 907 Kg STONE
0.9 - 4.54 MT STONE

Note:
The soundings and elevations are based on Low Water Datum (LDW), Lake Michigan. 0.0 feet LWD is at elevation 576.8 mean water level at father point, Quebec (International Great Lakes Datum (IGLD) 1955).

Figure 3.

13. Biological Assessment

Assessment is planned to span a 7 year period: 2 years prior to, 3 years during, and 2 years after construction. We will be looking for increased abundance and diversity of fish in spring, summer and fall in the vicinity of the reefs and existing breakwater. We will cooperate with the INHS to monitor spawning and hatching success of lake trout.

14. Measures of Success

Because only we are in the pre-construction phase, the assessment is incomplete. Monitoring of the construction and post-construction phases should prove interesting for comparison.

Success Rating: 1

15. Key References

None.

Correct citation for this contribution:

Moy, P.B. 1995. Burns Harbor major rehabilitation - submerged breakwater reefs, p.250–254. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 40

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1. Project Title: Pere Marquette River Rehabilitation Project

2. Contact

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3. Agencies Involved

Pere Marquette River Watershed Council
U.S Forest Service (Huron-Manistee National Forests)
Soil Conservation Service (Mason-Lake Conservation DiStrict)
Northwest Michigan Resource Conservation and Development Council
Michigan Council of Trout Unlimited
Michigan Department of Natural Resources - Fisheries Division

4. Restoration Goal

Rehabilitate river channel to provide salmonid spawning habitat, an adequate invertebrate food source and refuge habitat degraded by a large sediment bedload primarily from turn of the century logging and associated human activities.

5. Project Type

Stabilization of eroding sandbanks and road crossings, augmentation of refuge habitat, and physical removal of sediment bedload.

6. Background and Rationale

The Pere Marquette River is one of Michigan's rivers which was utilized to float logs to market. The lumber companies systematically removed log jams and other large woody debris from the river channel, rolled logs down the river banks, and floated them downstream. These activities introduced large amounts of sediment, especially sand, to the streambed.

Research conducted by the Hunt Creek Research Station proved removal of this sediment would increase salmonid production several hundred fold (Alexander and Hansen 1983). A streambank erosion site inventory was conducted by Northwest Michigan RC&D, Inc. in 1986 and provided the documentation to get the project started. This inventory identified 189 individual erosion sites and an estimated cost of $1.5 million. An inventory of the road/stream crossings followed in 1993 and was also conducted by Northwest Michigan RC&D, Inc.

In 1987, a partnership agreement was signed by the aforementioned agencies, based on the initial inventory, to rehabilitate the Pere Marquette River. Fundinq in the amount of $1 000 000 was pledged by the Fisheries Division – Michigan DNR.

7. Regulatory Considerations

a) Obtain an Inland Lakes & Streams (Act 346) permit from Land water Management Division – Michigan DNR.
b) Obtain a Soil & Sedimentation permit from Lake County.
c) File an Environmental Assessment (by U.S. Forest Service) as the Pere Marquette River is a National Scenic River and State Natural River.

8. Criteria

Major emphasis was placed on streambank stabilization as the majority of the sediment was originating from the 189 identified sites. The project commenced in the headwaters and proceeded downstream on a worst first basis, with only sandbanks being stabilized. Clay banks, with particle size of less than 125 mm, do not add detrimental sediment to aquatic systems.

9. Project Design

The entire toe of the eroding bank would be stabilized from below the waterline to four feet above the ordinary high water mark with fieldstone (natural) rock 15-30 cm in diameter. On many of the banks LUNKER structures (Vetrano 1988) were added as fish habitat. Following rock placement, plantings were made just above the rock, woody debris was placed on the bank to exclude human and animal traffic, collect leaf litter, and cool the predominantly south facing slopes. In addition, road crossings are being upgraded (in cooperation with County Road Commissions) and recreational access points (pedestrian and boat) are being improved to reduce sediment input. Sediment basins (sand traps) were also dug and maintained at key locations (Hansen 1973; Hansen et al. 1983).

10. Implementation

The project commenced the summer of 1987 and has continued through 1994. To date, a total of 132 erosion sites, having 7 724 m have been stabilized with 15 208 m^3 of fieldstone rock rip-rap and LUNKER structures. Some whole tree revetment has been used on clay banks and inaccessible locations. Finally, some conifer reforestation along tributary streams is being done to restore riparian forests and provide a source for large woody debris recruitment.

11. Degree of Environmental Intervention

The fieldstone rock was placed both by hand and by drag lines, excavators, and front end loaders. Fieldstone rock was used as it is native and found throughout the streambed. Native vegetation was used in revegetation areas above the fieldstone. The rock was overwhelming at first, but began to green up by the end of the summer of placement. Within 2-3 years, the rock rip-rap had a cover of annual plants.

12. Cost

Fisheries Division – MDNR	$863 096
U.S. Forest Service – (Dept. of Ag.)	$221 648
Local Match	$188 000
Trout Unlimited	$40 000
	$1 312 744

Most of the work was done by contractors through a bid procedure, but some was done by the Michigan Youth Corps and Dept. of Corrections labor crews.

13. Biological Assessment

Mark and recapture salmonid population estimates by electrofishing were done prior to the bank stabilization and will continue. Young-of-the-year brown trout populations have increased several hundred percent (some years) from near zero in the treated zones, while they have remained near zero in untreated zones. Visual observations of stream morpholoqy are also made annually.

14. Measures of Success

The long-term goal of increased brown trout populations will be measured by electrofishing over the next decade. Early indications are that populations will increase substantially and eliminate the need for supplemental stocking of hatchery brown trout.

Success Rating (early results): 4

15. Key References

Alexander, G.H., and Hansen, E.A. 1983. Sand sediment in a Michigan trout stream Part II. Effects of reducing sand bedload on a trout population. N. Amer. J. Fish. Manage. 3: 365-372.

Alexander, G.R., and Hansen, E.A. 1986. Sand bedload in a brook trout stream. N. Amer. J. Fish. Manage. 6: 9-23.

Bassett, C.E. 1988. Rivers of sand: Restoration of fish habitat on the Hiawatha National Forest, p. 43-48. *In* T.W. Hoekstra and J. Capp [*editors*]. Integrating Forest Management for Wildlife and Fish. USDA Forest Service General Technical Report NC-122, North Central Experiment Station, St. Paul, MN.

Hansen, E.A. 1971. Sediment in a Michigan trout stream, its source, movement, and some effects on fish habitat. USDA Forest Service Research Paper NC-59, North Central Experiment Station, St. Paul, MN.

Hansen, E.A. 1973. In-channel sediment basins - a possible tool for trout habitat management. Progr. Fish-Cult. 35: 138-141.

Hansen, E.A., Alexander, G.R., and Dunn, W.H. 1983. Sand sediment in a Michigan trout stream Part. I. A technique for removing sand bedload from streams. N. Amer. J. Fish. Manage. 3: 355-364.

Sedell, J.R., Swanson, F.J., and Gregory, S.V. 1984. Evaluating fish response to woody debris, p. 222-245. *In* Proceedings of Pacific Northwest Stream Habitat Management Workshop. California Cooperative Fishery Research Unit, Humboldt State University, Arcata, CA.

Vetrano, D.M. 1988. Unit construction of trout habitat improvement structures for Wisconsin coulee streams. Wisc. Dep. Nat. Resour. Admin. Rep. No. 27: 35p.

Correct citation for this contribution:

Rozich, T. 1995. Pere Marquette River Rehabilitation Project, p. 255–258. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 41

1. **Project Title: Effects of Beach Nourishment on the Nearshore Environment, Lexington Harbor, Lake Huron**

2. **Contact**

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Tel.: (313) 994-3331 ext 235; FAX: (313) 994-8780; E-mail: (cc-mail) R8 NFRC.GL

3. **Agencies Involved**

U.S. Army Corps of Engineers, Coastal Engineering Research Center, Kingman Building, Fort Belvoir, Virginia 22060, USA
National Biological Service, Great Lakes Science Center (NBS-GLSC), 1451 Green Road, Ann Arbor, MI 48105, USA

4. **Restoration Goal**

Mitigate beach erosion attributable to the installation of a small watercraft harbor of refuge, which interrupted alongshore movement of sediments and created sediment-starved beaches on prevailing downcurrent side. Assess effects of beach nourishment project on nearshore aquatic biota and habitats.

5. **Project Type**

Move accumulated beach sediments on upcurrent side of harbor to sediment-starved beaches on down current side; also nourish starved beaches with sediments of similar composition from a near-by borrow site on land. Conduct a "before and after" study of the project area to determine the short-term effects of the beach nourishment project on the nearshore aquatic biota and habitats.

6. **Background and Rationale**

In the late 1970's the U.S. Army Corps of Engineers (Corps) constructed a harbor of refuge for small watercraft on the shoreline of Lake Huron at Lexington, Michigan. The harbor provided the required shelter for small craft but also interrupted alongshore transport of sediment. This disruption of sediment transport created a sediment accretion area on the north side of the harbor and caused the beach to expand lakeward while starving the beaches to the south and causing them to recede landward to the base of the headland. The Corps designed a beach nourishment project to restore the beach-face profile north and south of the harbor to near pre-harbor condition and asked NBS-GLSC (then the U.S. Fish and Wildlife Service-Great Lakes Fishery Laboratory) to monitor the project for effects on nearshore aquatic biota and habitats. The nourishment project and the assessment study were performed in the early 1980's.

7. Regulatory Considerations

The Corps was the permitting agency and they contracted the nourishment work and the biological assessment. The Fish and Wildlife Coordination Act provided for project review by the U.S. Fish and Wildlife Service.

8. Criteria

Restore nearshore lake bed and beach front on both sides of the harbor to near-normal conditions as determined from adjacent reference areas and anecdotal site information that preceded harbor construction; cause no significant adverse impact on aquatic biota or habitats in the project area; and restore affected areas to near-normal condition.

9. Project Design

The Corps designed the beach nourishment project. The NBS-GLSC designed the "before and after" study that assessed project effects. The assessment study was conducted along an 8.4 km segment of shoreline roughly centered on the harbor. Aerial photography was used to document changes in the shoreline and the beach-face profile. Physical and biological data were collected at preset time intervals (June-October 1980, before and during project; and June-November 1981, after project) and at preset depth intervals, on four transects extending from the shoreline to the 5 m depth contour. Physical data collected were sediment grain size, suspended particulate matter, turbidity, temperature, and dissolved oxygen level. Biological data collected were kinds and numbers of macrozoobenthos, and kinds, numbers, and sizes of fish.

10. Implementation

The transport and placement of beach nourishment sediments occurred in October 1980. About 54 000 m^3 of sediment was moved from the shoreline accretion site on the north side of the harbor to the shoreline nourishment site on the south side of the harbor; an additional 19 000 m^3 sediment was trucked to the nourishment site from a nearby commercial borrow site on land. The assessment study lasted about 3 years. The field portion of the study extended from June 1980 to November 1981. The field work was performed from the shoreline and from a small boat. Weather and sea conditions controlled the work schedule particularly in the fall when storms were common. Macrozoobenthos sample reduction and analysis was typically labor intensive.

11. Degree of Environmental Intervention

The beach sediments and those from the borrow site were excavated and moved by land to the nourishment site with large equipment, including trucks. Bulldozers were used to spread the sediments along the beach front. Additional details may be available from the Corps. Some local, minor increases in turbidity probably occurred during the excavation of beach sediments and the deposition and spreading of sediments in the starved beach area. The lakeward extension of the shoreline in the sediment-starved area may have displaced some aquatic organisms, but the total effect, if any, was probably minor because the biota in the surf zone on this exposed beach were highly mobile (fishes), sparse (large benthic invertebrates), or adapted to life within wet sediments (psammon).

12. Cost

We have no estimates of the cost of the beach nourishment project. The Corps may be able to provide them. Assessment costs covered under the contract with the Corps were approximately $50 000.

13. Biological Assessment

A 2 year before and after study with preselected effect and reference areas was performed. The study involved measurement of physical and biological variables in the study area. The study protocol and results are detailed in a published report (see item 15 below).

14. Measures of Success

The nourishment project was completed as planned. The assessment was completed as planned and demonstrated that the beach nourishment project had no major adverse effect on substrate particle-size distribution, water quality, macrozoobenthos, or fish in the study area. Marked changes in the shoreline and beach-face profile occurred in the immediate vicinity of the harbor as a result of the nourishment activity. However, the only obvious change that persisted 14 months after the nourishment project was completed (i.e., in November 1981 when the field portion of the assessment study was completed) was a moderate lakeward extension of the shoreline in the area immediately south of the harbor.

Success Rating: 4

The project was successful as designed. The project site is in a hydrodynamically dynamic zone and, therefore, the study would have benefited from assessment of longer duration to document annual physical and biological variation.

15. Key References

The effects of the beach nourishment project on the beach face and shoreline and all aspects of the assessment study are detailed in:

Nester, R.T., and Poe, T.P. 1982. Effects of beach nourishment on the nearshore environment in Lake Huron at Lexington Harbor (Michigan). U.S. Army Corps of Engineers, Coastal Engineering Research Center Miscellaneous Report No. 82-13, Springfield, Virginia.
The report is presumably available from the National Technical Information Service in Washington, DC.

Correct citation for this contribution:

Edsall, T.A. 1995. Effects of beach nourishment on the nearshore environment, Lexington Harbor, Lake Huron, p. 259–262. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 42

1. Project Title: Ecological Effects of Rubble-Mound Breakwater Construction and Channel Dredging at West Harbor, Ohio (Western Lake Erie)

2. Contact

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Tel.: (313) 994-3331 ext. 255; FAX: (313) 994-8780; E-mail: (cc-mail) R8 NFRC.GL

3. Agencies Involved

U.S. Army Corps of Engineers, Washington, DC 20314-1000, USA (Under EIRP Work Unit 31632)
National Biological Service, Great Lakes Science Center (NBS-GLSC), 1451 Green Rd., Ann Arbor, MI 48105, USA

4. Restoration Goal

Build breakwaters on either side of the entrance to West Harbor, Ohio, and dredge channel between them to permit access to and from western Lake Erie by small water craft under all weather conditions. Assess adverse ecological impacts of breakwater construction and dredging on area biota.

5. Project Type

Modify shoreline/channel geometry at harbor entrance by construction of two breakwaters extending offshore and dredging a channel approach to the harbor between them to a uniform depth. Conduct studies of water quality and the distribution and abundance of periphyton, macrozoobenthos, and fishes in nearby habitats before, during, and after construction.

6. Background and Rationale

The study area was located in southwestern Lake Erie along a beach shoreline in shallow (0-4 m) water at the entrance to West Harbor, a natural stream channel. High-energy waves eroded parts of the beach and filled in the channel, restricting access to the harbor by sport-fishing boats. To improve access to the harbor, the U.S. Army Corps of Engineers (Corps) designed and constructed breakwaters consisting of large (0.9-2.7 tonnes) limestone boulders underlain by smaller (25-350 kg) stones on either side of the channel and dredged the channel between them to a uniform depth of 3 m. The east breakwater was connected to shore and extended 480 m offshore to water about 3.5 m deep. The west breakwater was not connected to shore (to improve water circulation) and extended offshore to water about 3 m deep. The Corps asked NBSGLSC (then the U.S. Fish and Wildlife Service, Great Lakes Fishery Laboratory) to document changes in water quality, bottom sediments, and biota before, during and after construction on the breakwaters at five transects near the harbor mouth.

7. Regulatory Considerations

The Corps was the permitting agency; they contracted with the private sector for construction and with NBS for the biological assessment. The Fish and Wildlife Coordination Act provided for project review by the U.S. Fish and Wildlife Service.

8. Criteria

Compared with site information collected prior to construction, project activities should cause no significant adverse impact on aquatic biota or their habitats in the project area and restore the area to pre-project water depths and substrate conditions.

9. Project Design

The Corps designed the breakwaters and channel dredging. NBS designed the assessment of project effects on water quality, substrates, and biota at 5 transects perpendicular to shore along a 4 km segment of the shoreline roughly centered on the harbor mouth. Three transects (II, III, and IV) were located near the proposed breakwater construction site; two (I and V) were located 0.8 km northwest and 2.0 km southeast of the harbor entrance in reference areas outside the construction site where the composition and slope of the lake bottom were similar to those in the construction site. Transect III in the channel to West Harbor assessed changes in water quality and biota occurring as a direct result of deepening and extending that channel. Water quality data collected on transects and breakwaters included bottom type, dissolved oxygen, water temperature, suspended particulate matter and turbidity. Macrozoobenthos, periphyton, and fish were identified to the lowest practical taxonomic level. Fish were collected on transects and near breakwaters with a beach seine and a 8 m semi-balloon bottom trawl.

10. Implementation

Limnological and fishery surveys were conducted on the transects using large and small research vessels in August of 1981, 1982, and 1983 and on breakwaters in April, July and September of 1982 and 1983. Breakwater construction and channel dredging were done between August 1981 and November 1882. From October 1982 to August 1983, without notifying the NBS or the Corps, the Ohio DNR constructed four offshore breakwaters southeast of the entrance to West Harbor to protect the public beach there from erosion. This activity confounded the "after" portion of the NBS assessment.

11. Degree of Environmental Intervention

Breakwaters were constructed with large dump trucks and barge-mounted cranes. Dredging with a barge-mounted hopper dredge caused significant, short-term increases in turbidity and decreases in dissolved oxygen near the construction site. Stream flow between the breakwaters was diverted and interrupted for about 2 months during channel dredging. Marked adverse changes in water quality (dissolved oxygen) were noted at the study site in 1983 following construction and dredging activities at West Harbor and during construction of offshore breakwaters by ODNR.

12. Cost

We have no estimate of the cost to design and construct the breakwaters and dredge the channel; please contact the Corps for that information. Costs of the NBS assessment study were about $50 000.

13. Biological Assessment

This assessment showed that rubble-mound breakwater construction and channel dredging at the mouth of West Harbor had no detectable adverse effects on macrozoobenthos and fishes. The breakwaters provided suitable substrate for colonization by periphyton, especially Cladophora, and a more diverse assemblage of macrozoobenthos (46 taxa), including 27% *Gammarus*, than was found in nearby sandy substrates (36 taxa), presumably because the breakwaters offered more protection from wave action and a wider variety of habitats than the surrounding lake bottom. Breakwater construction and channelization caused fish to avoid the construction site in April and July of 1982 but had no lasting adverse effect on the distribution or abundance of fishes near the site.

14. Measures of Success

"After" aspects of the assessment in 1983 were confounded by marked decreases in dissolved oxygen at the study site that can not be ascribed with certainty to breakwater construction and channelization at the West Harbor site because the State of Ohio constructed offshore breakwaters near the study site then. Other aspects of the biological assessment were successful and showed that the breakwaters were being rapidly colonized by a wide variety of plant and animal life. Additional study would have been needed to determine when colonization of the breakwaters by periphyton, macrozoobenthos, and fish reached equilibrium.

Success Rating: 4

The project was successful as designed but would have benefited from a longer period of assessment.

15. Key References

All data and findings of the biological assessment by NBS are in:

Manny, B.A., Schloesser, D.W., Brown, C.L., and French, J.R.P. 1985. Ecological effects of rubble-mound breakwater construction and channel dredging at West Harbor, Ohio (Western Lake Erie). Technical Report EL-85-10, prepared by U.S. Fish and Wildlife Service for the U.S. Army Corps of Engineer Waterways Experiment Station, Vicksburg, Mississippi.

This report is presumably available from the National Technical Information Service in Washington, DC.

Correct citation for this contribution:

Manny, B.A. 1995. Ecological effects of rubble-mound breakwater construction and channel dredging at West Harbor, Ohio (Western Lake Erie), p. 263–266. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 43

1. Project Title: Evaluation of Tawas Artificial Reef as Fish Spawning Habitat

2. Contact

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E-mail: (cc-mail) R8 NFRC.GL or nealfost@umich.edu

3. Agencies Involved

Walleyes for Iosco County, c/o Walter Snow, 1746 Cowan Drive, National City, MI 48748, USA
Michigan Sea Grant Extension Office, Cooperative Extension Service, P.O. Box 599, Tawas City, MI 48764, USA
Michigan Department of Natural Resources (DNR), Alpena Fisheries Station, 4343 M-32 West, Alpena, MI 49707, USA
U.S. Fish and Wildlife Service (FWS), Alpena Fisheries Resources Office, Federal Building #203, Alpena, MI 49707, USA
National Biological Service, Great Lakes Science Center (NBS-GLSC), 1451 Green Rd., Ann Arbor, MI 48105, USA

4. Restoration Goal

Installation of a rock-rubble reef to enhance fish spawning and reproduction and to improve fishing opportunities in nearshore, protected areas.

5. Project Type

Conduct a study of the project area to determine effects of the reef placement on aquatic biota and habitat in the surrounding bay. Assess use by and behavior of fish during spawning on Tawas reef using a remotely operated vehicle (ROV) with underwater video camera. Determine egg deposition on the reef using egg traps. Conduct an egg/fry survival study on the reef using fry traps. Conduct a mark-recapture study of adult lake trout during the spawning period.

6. Background and Rationale

In August 1987, the Michigan DNR, with the assistance of a local sportsfishing organization, Walleyes for Iosco County, constructed Tawas artificial reef to improve recreational fishing in Tawas Bay. Post-construction assessment netting by the Michigan DNR during fall 1987-89 found dense aggregations of lake trout closely associated with the reef. In spring 1990-91, the Michigan DNR conducted fry trapping to document any successful reproduction on the reef. Live lake trout and lake whitefish fry were collected in these traps. In fall 1989, the Michigan DNR asked the NBS-GLSC to observe activity and behavior of these fish with the ROV, and possibly to determine if any spawning activity was taking place on the reef. An assessment to determine the extent of egg deposition by lake trout (and lake whitefish) on Tawas reef was performed during 1989-1993.

7. Regulatory Considerations

The Michigan DNR was the permitting agency for construction of the reef; they were also the lead agency involved in pre- and post-construction biological assessment. The NBS-GLSC provided pre- and post-construction habitat/substrate assessment and further biological assessment.

8. Criteria

Create habitat suitable for walleye (and other fish species) spawning, protection, and survival. Improve local angling success by creating habitat that would attract desirable fish species to more accessible areas.

9. Project Design

The Michigan DNR supervised materials selection, construction of the reef, and performed the initial gill net assessments. The NBS-GLSC designed the spawning behavior/egg deposition study. The behavioral study used the ROV to obtain video observations of lake trout during the spawning period, fall 1989-1993. The observations included (1) estimation of relative density of lake trout in the vicinity of the reef versus in the surrounding "sand flats" area of the bay and (2) direct observation of prespawning behavior on the reef with comparison to observations made on fish at natural reef sites and under laboratory conditions. The egg deposition study was conducted during fall 1990-1993, using two hundred 20.3 cm diameter, individually numbered egg traps set on the reef and on the surrounding sand substrate. Data collected included trap location, numbers of lake trout and lake whitefish eggs (live and dead), macroinvertebrates (including zebra mussels), trapped fish, and relative amounts and composition of sediment and detritus in each trap. The FWS (with assistance from NBS-GLSC and the Michigan DNR) initiated a mark-recapture study to document the presence and relative abundance of naturally produced (no finclip) adult lake trout that may be present at the reef during the spawning period. This study began in fall 1992, and is presently (1995) ongoing.

10. Implementation

The construction of the Tawas artificial reef occurred within 1 day, in August 1987 (Figure 1). By October of that year, lake trout began congregating around the reef area in significantly greater numbers than elsewhere in the bay. Fry traps were set, by divers, in the Spring 1990-91, over a 2-

4 week period (April/May) to collect larval fish that may have been produced on the reef. The study to observe lake trout prespawning behavior and egg deposition began in October 1989. ROV operations occurred at night for 1 to 2 nights, usually around the period of peak lake trout concentrations on the reef. Egg traps were generally set from mid-October through late November, a period that included all spawning activity of lake trout and most spawning activity of lake whitefish. Traps were set in gangs (chains) of 25 (1991-1993) to 50 (1990) traps per gang and deployed and retrieved from a small boat. The ROV was used to document the position of each trap relative to the reef. The mark-recapture study was initiated in the fall 1992, and was performed over a 3-week period (2-3 nights/wk) encompassing the lake trout spawning period (mid-October through early-November). Fish were collected using a 91-183 m gill net set along the length of the reef. Nets were set after dark, and never exceeded more than 4 hours in the water to minimize fish casualties.

11. Degree of Environmental Intervention

The introduction of about 3 628 tonnes of limestone rock (15-30 cm dia) was accomplished using a self-unloader freighter. The rock was deposited in one continuous pile, approximately 450 m in length. While occupying a relatively small area relative to the size of the bay, the structure of the

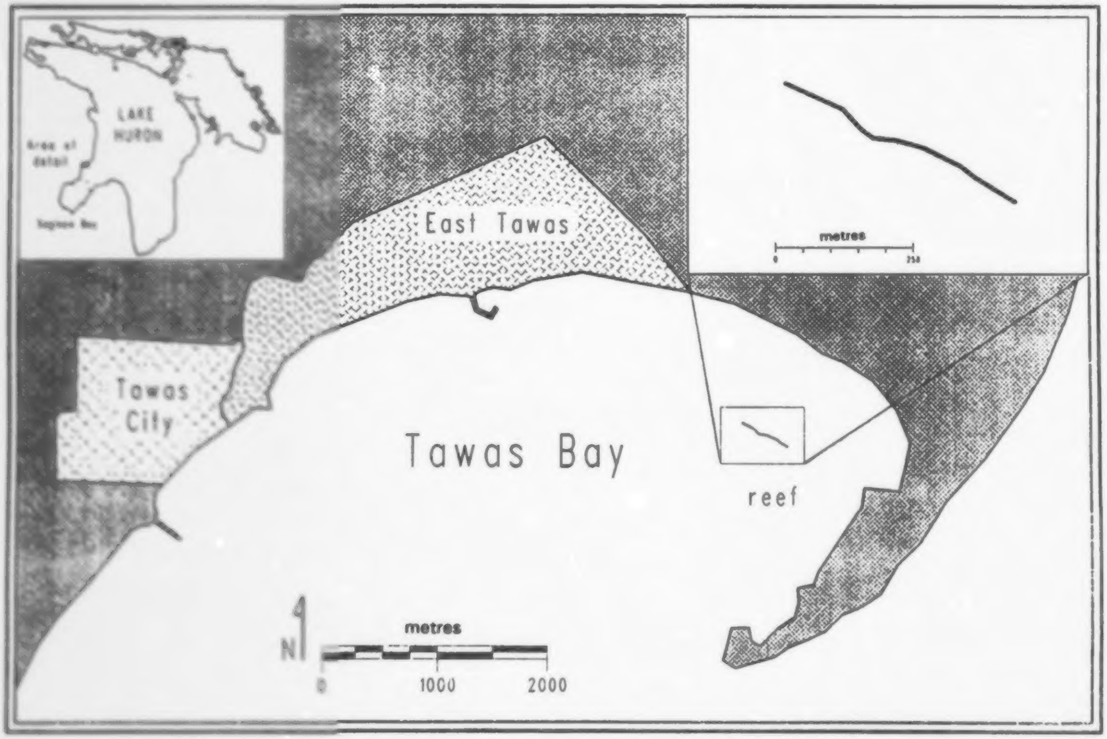

Figure 1.

immediate area is quite different from what it was prior to construction of the reef.

The east end of the reef area has shown an increase in the density and composition of aquatic macrophyte growth and accompanying settlement of finer-grained sediments than was present before installation of the reef. The reef itself has also become infested with zebra mussels, which were first detected on the reef in 1991. The effect that zebra mussels will have on the reef and surrounding biota has not yet been determined. However, the bay as a whole has shown little or no change as a result of reef construction.

12. Cost

The Tawas artificial reef cost an estimated $40 000 to build; however, much of the design, engineering, and materials were donated, making the actual cost difficult to determine. The per-year cost estimate for the behavior/egg deposition study is about $35 000, which includes about 2 months time for four researchers (about 5-10 days in the field, the rest for data processing and analysis), travel, equipment, and boat costs.

13. Biological Assessment

A 4-year study to document the use and usefulness of the Tawas artificial reef as a fish spawning site was performed. Qualitative underwater observations with an ROV of lake trout prespawning behavior helped in understanding physical and biological habitat conditions necessary for lake trout reproduction. Quantitative assessment with egg traps of egg deposition patterns further evaluated habitat and spatial preferences. Methodology and results of this study are detailed in a published manuscript (See "Key References"). In addition, assessment and documentation of fry production has been performed, indicating egg survival through the winter is possible on Tawas reef. Finally, assessment of the returning adult lake trout population has been initiated (1992) and is ongoing. Worthwhile additions to the assessment would be seasonal ichthyoplankton net tows and short-term gill net sets to determine utilization of the reef by other fish species.

14. Measures of Success

Relatively consistent numbers of lake trout eggs have been collected in the egg traps every year at Tawas reef. ROV surveys also documented a relatively stable, dense lake trout population congregating on the reef during the spawning period. The ROV and mark-recapture surveys also confirm that the population currently consists of about 99% hatchery produced.(i.e., finclipped) adults. Documentation of naturally produced (i.e., no finclip) adult lake trout returning (presumably homing) to the reef would be the most critical evidence that the artificial reef has actually enhanced lake trout production in Tawas Bay.

(Lake trout)
Success Rating: 4
The project was successful in creating lake trout spawning habitat. It is still unknown whether egg

deposition on the reef has resulted or will result in an increased proportion of wild (unfinclipped) spawners.

(Walleye)
Success Rating: 3

The original goal of the reef was increased walleye production / angling success; however, little is known about the reef as a walleye attractor or as a site for walleye reproduction.

15. Key References

Foster, N.R., and Kennedy, G.W. 1995. Egg deposition by lake trout and lake whitefish at Tawas Artificial Reef, Lake Huron, 1990-1993, p. xx-xx. *In* T. Edsall, M. Munawar, and J. Leach [*editors*]. Lake Huron Basin Symposium, September 1993. Elsevier Books. (In press)

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Perkins, D.L., and Krueger, C.C. 1995. Dynamics of reproduction by hatchery-origin lake trout (*Salvelinus namaycush*) in Lake Ontario. J. Great Lakes Res. (In press)

Schreiner, D., Bronte, C.R., Payne, N.R., Fitzsimons, J.W., and Casselman, J.M. 1995. Use of egg traps to investigate lake trout spawning in the Great Lakes. J. Great Lakes Res. (In press)

Correct citation for this contribution:

Foster, N.R., and Kennedy, G.W. 1995. Evaluation of Tawas artifical reef as fish spawning habitat, p. 267–271. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 44

1. Project Title: Fox River Walleye Habitat Improvement

2. Contact

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3. Agencies Involved

Wisconsin Department of Natural Resources (DNR)
City of De Pere, Wisconsin, Department of Public Works

4. Restoration Goal

To enhance and/or create spawning habitat for walleye in three locations in the Fox River.

5. Project Type

Create new spawning habitat for walleye at two locations in the Fox River. Enhance spawning habitat in one location by increasing desirable substrate adjacent to a good quality, highly used spawning area.

6. Background and Rationale

The Fox River, a major tributary into Lake Michigan's Green Bay, has been subjected to a high degree of urbanization and industrialization since the turn of the century. Construction of power dams, locks and regularly maintained navigation channels, combined with an industrial setting including 15 pulp and paper mills and 11 municipal sewage treatment plants makes the Fox River one of the most densely developed industrial rivers in the world. As a result, water quality declined throughout this century. Because of high BOD levels, dissolved oxygen concentrations achieved only low levels and failed to exceed two parts per million during most of the year. Locks and dams effectively blocked upstream migration of most species, including walleye, limiting access to suitable spawning areas. In addition, most naturally occurring substrate was degraded or destroyed.

Implementing the 1972 Clean Water Act led to improved water quality by the late 1970's through reduction in BOD levels. When dissolved oxygen levels continuously exceeded 5 mg/L, the Wisconsin DNR attempted to rehabilitate walleye stocks by introduction of walleye fingerling in

1977 and fry between 1978-1984 (Schneider et al. 1991). By 1985, stock size and spawning densities at suitable spawning sites were sufficient to realistically expect successful reproduction. Reproduction was documented in 1985 and successful spawning sites were identified (Balcer et al. 1986).

Only limited areas of appropriate walleye spawning habitat exist along the Fox River below the De Pere dam. We speculated that if walleye stocks increased, additional spawning substrate would be required and that the increase of suitable habitat would in turn raise the probability of successful recruitment. As opportunities presented themselves, we worked with local municipal governments to incorporate walleye spawning substrate into design plans of proposed bank stabilization and construction projects along the Fox River. Between 1989-1992 three projects gave us this opportunity.

7. Regulatory Considerations

a) Preliminary meetings with municipality agreeing to the extent and requirement of in stream, habitat construction;
b) Completion of joint State/Federal Application for Water Regulatory Permits and Approvals;
c) Completion of Wisconsin DNR Water Regulation field investigation and/or assessment;
d) Obtain a Wisconsin DNR Navigable Water, Harbor and Navigation (Chapter 30) permit;
e) Conform and comply with Water Regulation and Zoning inspection reports.

8. Criteria

Preferred walleye spawning habitat:

- Water depth less than 2.4 m (optimal 0.9-1.8 m);
- Rock/cobble, gravel substrate (1.8 m cobble with interstitial spaces containing smaller materials);
- Current velocities at the depth of the substrate are sufficient to minimize sedimentation.

9. Project Design

Three projects have been undertaken and designed to increase recruitment of walleye (Figure 1) since 1989. These projects include:

- In 1989, as part of a stream bank stabilization/sewer repair project, creating 111 m^2 of spawning habitat in three locations at the Brown County Fairgrounds.
- In 1990, as part of a stream bank stabilization/shore front improvement project, enhancing and enlarging an existing walleye spawning site at Voyageur Park creating 3 066 m^2 of additional habitat along 401 m of stream bank (Figure 2).
- In 1992 establishing 2 973 m^2 of spawning habitat, as part of the construction of a new boat launching/marina facility on the east shore of the Fox River (Figure 3).

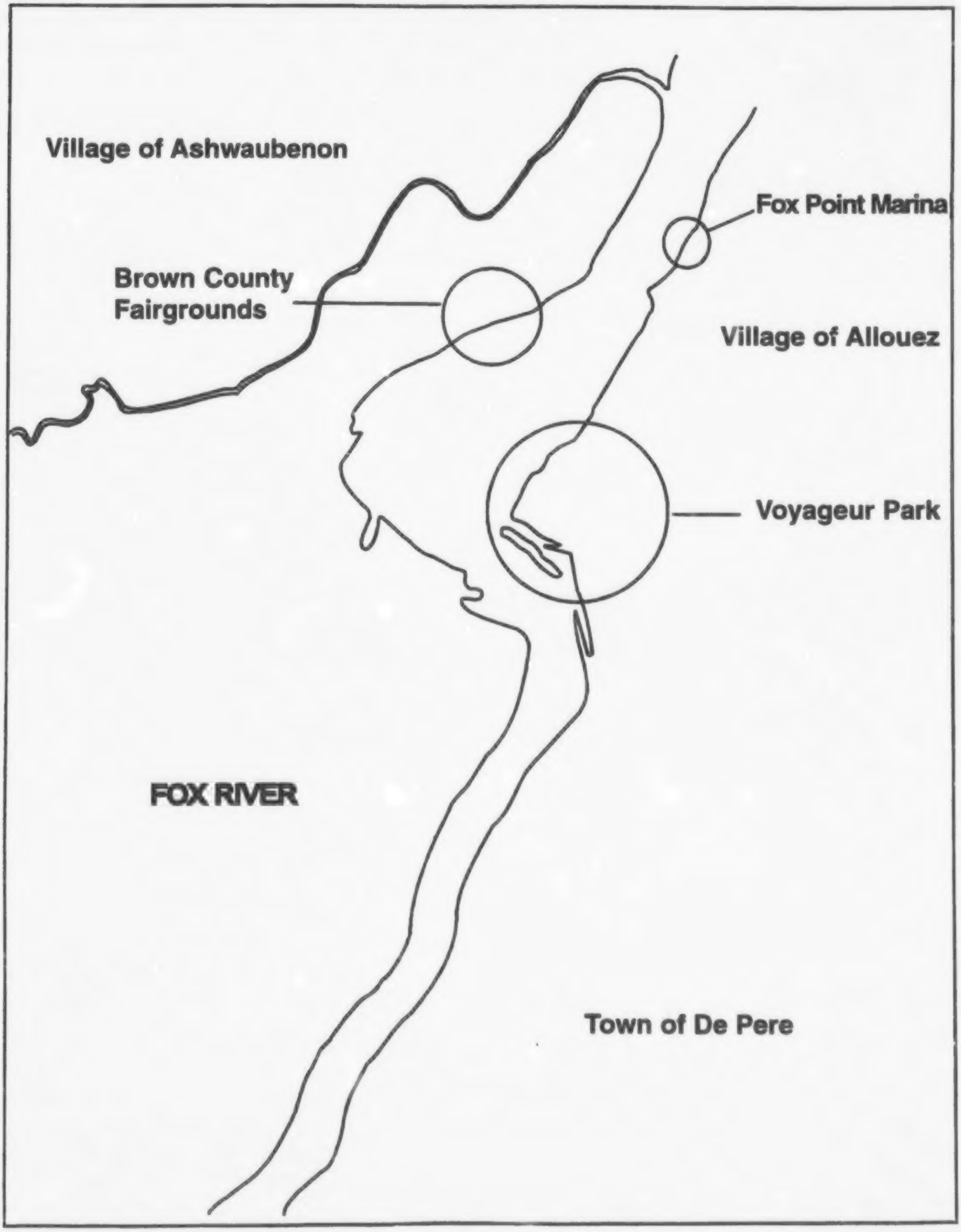
Village of Ashwaubenon
Fox Point Marina
Brown County Fairgrounds
Village of Allouez
Voyageur Park
FOX RIVER
Town of De Pere

Figure 1. Site locations.

We attempted to design criteria for the placement and type of materials used in the projects based on the characteristics found at sites in the Fox River where spawning densities were high and spawning had been successful. Each of the projects required that the following characteristics be designed into the project:

- Site locations will require water depths < 1.8 m for placement of substrate. However, consideration was given to the range of river elevations that could be expected on an annual basis because of fluctuation in water elevations on Lake Michigan/Green Bay.
- If possible, a 3:1 slope will be incorporated into the design in order to maximize the surface

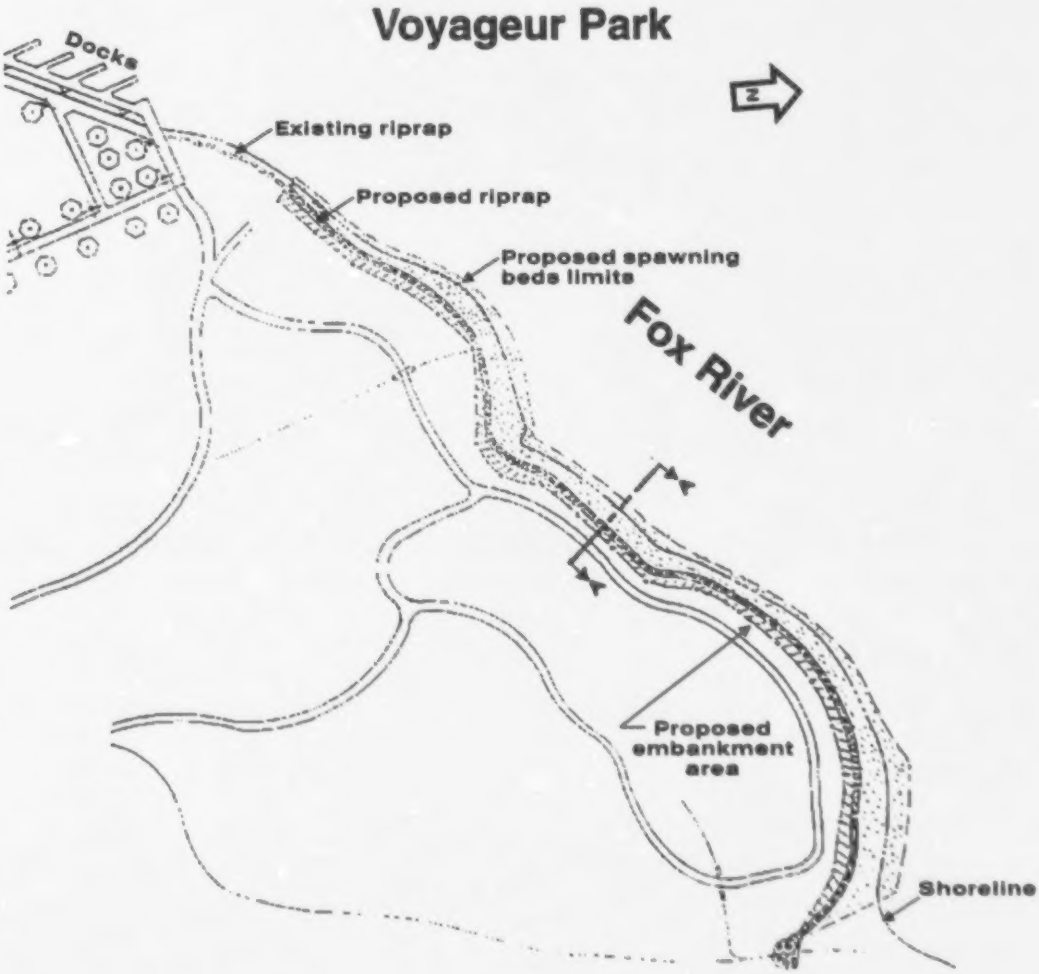
Voyageur Park
Docks
N
Existing riprap
Proposed riprap
Proposed spawning beds limits
Fox River
Proposed embankment area
Shoreline

Figure 2.

Fox Point Marina

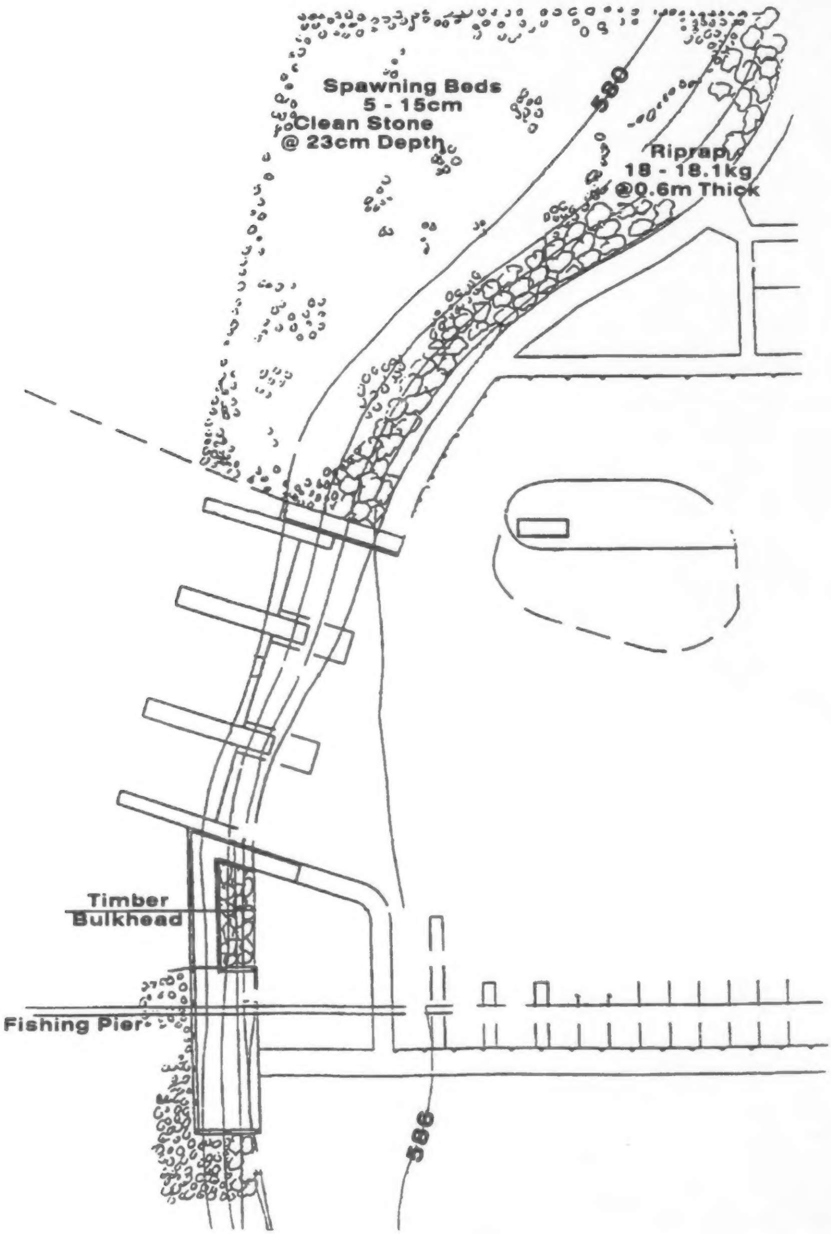
Spawning Beds
5 - 15cm
Clean Stone
@ 23cm Depth
580
Riprap
18 - 18.1kg
@0.6m Thick
Timber
Bulkhead
Fishing Pier
586

Figure 3.

area available for spawning under various river elevations (Figure 4).

- Substrate will be constructed of clean, silt free, dolomite limestone, crushed to size (5-15 cm) with 50-60% composed of 1.8 m material laid to a depth of at least 20 cm.

10. Implementation

In each of the projects, the Wisconsin DNR - Bureau of Water Regulations and Zoning informed Fisheries Management of proposals early in the project design process. By doing so, preliminary meetings were held with the municipality and their consultant engineers. At these meetings opportunities exist for discussion regarding the appropriateness of including spawning habitat into the design of the project. In some cases the addition of spawning habitat actually lowered the initial cost projections while maintaining the integrity of the project. In others it has only minimally added to the initial cost. In all cases, early intervention in the planning process will reduce labor and construction costs for placement of materials in the stream bed. In our situation there was an added benefit in that the municipalities chose to cover the cost of the habitat development.

In each case, methods and time of implementing the projects varied. Each will be discussed separately below:

1989, Brown County Fairgrounds:
Construction was conducted during July and August of 1989. A silt screen was in place during most of the construction period. After repair of the sewer line was complete, the shoreline was

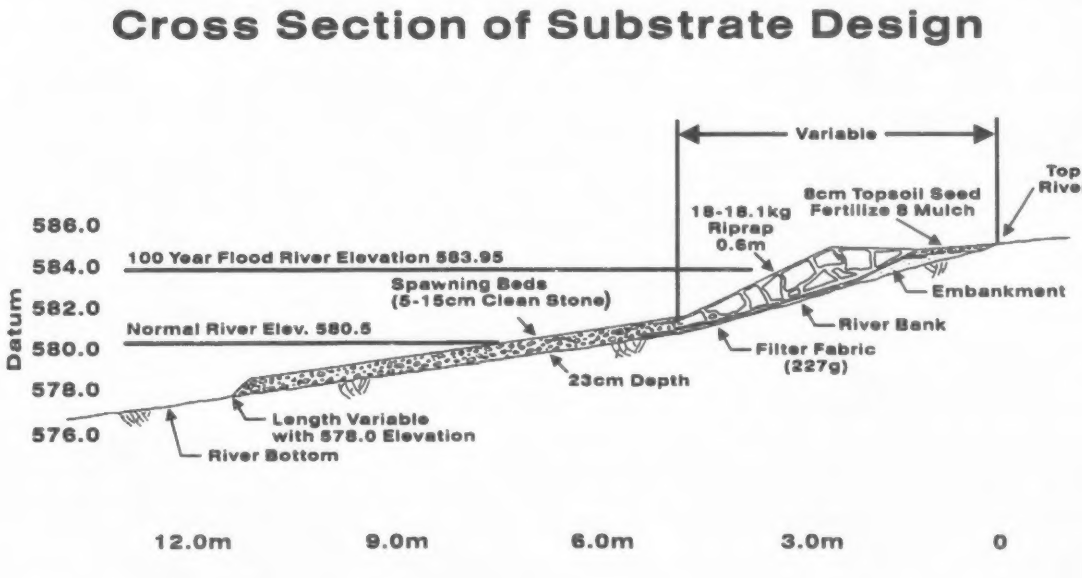
Cross Section of Substrate Design
Variable
Top River
8cm Topsoil Seed Fertilize & Mulch
18-18.1kg Riprap 0.6m
100 Year Flood River Elevation 583.95
Spawning Beds (5-15cm Clean Stone)
Embankment
River Bank
Normal River Elev. 580.5
Filter Fabric (227g)
23cm Depth
Length Variable with 578.0 Elevation
River Bottom
Datum
586.0
584.0
582.0
580.0
578.0
576.0
12.0m
9.0m
6.0m
3.0m
0

Figure 4.

reconfigured and stabilized. Three locations along the shore were selected as sites to create spawning habitat. These sites were chosen because the configuration of the shoreline projected into the water forming small points. The surface area for each of the sites was approximately 122 m and extended from the stream bank about 2.4 m. Placement of materials was with a backhoe with construction done entirely from shore. The recommended materials were to be 0.6-1.8 m clean, crushed, dolomite limestone; however, 63 tonnes of 0.3-0.6 m material was placed before the mistake was noted. Walleye were able to use the new habitat in the spring of 1990.

1990, Voyageur Park:
Construction began in early summer of 1990 but instream work was done during July and August. The 907 tonnes of the appropriate material (0.6-1.8 m, clean, dolomite) was placed on a 3:1 slope extending 9 m into the water. The work was done entirely from shore using a backhoe. Placement occurred on nearly 402 m of shoreline, creating 3 066 m^2 of spawning substrate. First spawning over the new substrate occurred in 1991.

1992, Fox Point Marina:
Construction of the launching ramp and parking ramp began in the summer of 1992. A dike was created and the area dewatered to do the instream work. A 61 × 49 m area north of the piers and launching area was established as spawning habitat. A total of 1 428 tonnes of 0.6-1.8 m stone,on a 3:1 slope were placed in the area. Instream construction work was completed in early March of 1993. First spawning over the material occurred in 1993.

11. Degree of Environmental Intervention

Original materials of the stream bed were not removed. In all cases, the new material was placed over the stream bed's substrate. Silt screens and dikes were used to prevent downstream sedimentation and is recommended in all sites where soft sediments may occur. Construction occurred during low flow periods, February-March and/or July-August. These time periods also avoided spawning periods of other species. No mortality to fish or macroinvertebrates was documented during construction.

12. Cost

The costs for each of the three projects reflect the expense of delivery and placement of the materials in the stream bed. All costs were born by the municipalities. Engineering and on site supervision could not be separated from the total project costs. Because heavy equipment was already on site for other construction purposes, the cost of placing materials would be substantially higher if a habitat improvement project was attempted by itself. However, these costs illustrate the savings that can be made by taking advantage of opportunities in other construction projects.

Construction Costs:

Brown County Fair Grounds:	
63.5 tonnes@ $5.24/tonne	
111 m^2 = $3.01/$m^2$	$332.74
Voyageur Park:	
907 tonnes@ $10.20/tonne	
3066 m^2 = $3.01/m	$9 251.40
Fox Point Marina:	
1429 tonnes @ $14.23/tonne	
2973 m^2 = $6.78/m2	$20 477.57
Subtotal Construction	$30 061.71

Spring and Fall Assessment Costs (pre and post construction, 1987-1993):

Field Crew:	15 person weeks/year (7 years)	$35 000.00
Biologist:	2 weeks/year (7 years)	$9 800.00
Supplies & Expenses (7 years)		$3 500.00
Subtotal Assessment		$48 300.00
Total Costs of Projects to Date		**$78 361.71**

13. Biological Assessment

Mark and recapture population estimates of spawning age walleye have been made by fyke net surveys each spring since 1986. Relative abundance of YOY walleye has been obtained through late fall electrofishing surveys in each year since 1987. In 1993 egg traps were randomly placed in the substrate at the Voyageur Park site and at all sites in 1994. We expect to continue these surveys through 1997.

14. Measures of Success

Although many variables may account for increased egg survival and fall fingerling recruitment, we have been encouraged by the results seen since improvements in habitat in the Fox River. In 1991, the first fall after spawning occurred on the Voyageur Park substrate, the relative abundance of fall fingerling walleye was 100 to 1 000 times greater than any other year-class we had measured. Since then, the average annual recruitment of fall fingerling for the 1991-1993 period has been 200-300 times greater than the 1987-1990 average. However, all sites do not appear to be equally successful.

The Brown County Fair Grounds:
This site does not appear to be producing walleye. Little spawning activity occurs at the site and no egg deposition has been documented. We feel that the area created was not extensive enough to attract adult walleye. The smaller sized material way also be inappropriate.

Success Rating: 3

Voyageur Park:
This site has exceeded our expectation. The area was extensively used by spawning walleye prior to the habitat enhancement project but has now become the area with the highest spawning density of any net location in the river. In 1993, egg deposition over the substrate was estimated at 5.2 million eggs.

Success Rating: 5

Fox Point Marina:
We documented egg deposition at the site in 1994. An estimated 67 300 eggs were deposited over the substrate, low levels, considering the surface area available on site. In 1993, the first year of spawning at the site, walleye density and spawning activity was low. By 1994, spawning density increased. As the abundance of spawning walleye increases, as we expect as the 1991 year-class matures, more walleye may be attracted to this site.

Success Rating: 1

15. Key References

Balcer, M.D., McCauley, D.J., Niemi, G.I., and Brooke, L.T. 1986. Ecological assessment of factors affecting walleye ova survival in the Lower Fox River. Final Report to U.S. Environmental Protection Agency, Environmental Research Laboratory-Duluth, MN. Co-op Agreement #CR-811723-02-0. 78p.

Schneider, J.C., Lychwick, T.J., Trimberger, E.L., Peterson, J.H., O'Neal, R., and Schneeberger, P.L. 1991. Walleye rehabilitation in Lake Michigan, 1969-1989, p. 23-61. *In* P.J. Colby, C.A. Lewis, and R.L. Eshenroder [*editors*]. Status of Walleye in the Great Lakes: case studies prepared for the 1989 workshop. Great Lakes Fish. Comm. Spec. Publ. 91-1.

Correct citation for this contribution:

Lychwick, T.L. 1995. Fox River walleye habitat improvement, p. 272–281. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 45

1. Project Title: Peterson Wetland Restoration Project

2. Contact

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3. Agencies Involved

U.S. Fish and Wildlife Service, East Lansing Field Office, 1405 South Harrison, Room 302, East Lansing, MI 48823, USA
Clinton County Drain Commission, 1017 South US-27, Suite 35-B Southpoint Mail, St. Johns, MI 48879, USA
Tel.: (517) 224-5160
Mid-Michigan Duck Hunters Association, 1884 W. Howell Rd., Mason, MI 48854. USA
Tel.: (517) 676-1168 [Contact: Mike O'Malley]
Ducks Unlimited

4. Restoration Goals

- Restore a 14 ha drained wetland;
- Reduce siltation and water volume entering the county drain, and subsequently, the Looking Glass River;
- Increase flood storage capabilities;
- Increase water quality;
- Provide habitat for wetland associated wildfire.

5. Project Type

Relocate county drain ditch and plug original ditch to restore the wetland.

6. Background and Rationale

The project is located on a 32 ha parcel in Section 1 of Watertown Township, Clinton County, Michigan. The initial site inspection occurred in December 1993 with actual earth moving initiated in February 1994.

This project restored wetland functions, in addition to fostering a productive working relationship with the Clinton County Drain Commission. The intended function of the Michigan County Drain

Commission is to move the water off the land, which conflicts with the goals of the U.S. Fish and Wildfire Service to preserve and restore wetlands. This project not only restored the wetland but also maintained adequate drainage for those landowners located upstream from the project site.

7. Regulatory Considerations

- The Michigan Department of Natural Resources has taken over implementation of Section 404 of the Clean Water Act, and also has permit authority for the State's Goemaere-Anderson Wetland Protection Act (P.A. 203) and Inland Lakes and Stream Act (P.A. 346). Michigan's Drain Code of 1956 (Act 40) is virtually exempt from State wetland regulations; thus, no permits were required for the county drain relocation.
- Recording of easement survey for relocated drain at Clinton County register of deeds office. Easement survey completed by a registered surveyor.
- Release of right-of-way by the landowner.
- Completion of drain relocation petition with the signatures of 5 landowners utilizing the county drain.
- Elevation data provided to Clinton County Drain Commission by a registered surveyor proving no adjacent landowners will be flooded by the restored wetland.

8. Criteria

- Establish permanent water depth averaging 30-60 cm.
- Combination of forested, scrub-shrub, and emergent wetland.

9. Project Design

The ditch plug was designed to act as the spillway for excess water. An earthen ditch plug was installed by first removing organic soil material from the ditch at the plug site. A cut was made on each side of the ditch to serve as an area to key the plug, Heavy clay soils were used and filter fabric was placed on the plug. Concrete rip-rap was placed on top of the fabric in a jigsaw puzzle fashion to establish the desired water elevation.

The relocated drain was 208 m in length, with 3:1 sloped sides and a bottom width of 0.90 m. The tile inlet consisted of a 3 m section of corrugated metal pipe with rip-rap installed to reduce erosion. The ditch spoils were leveled and seeded (Figure 1).

Four wood duck nesting boxes were built and donated by the Mid-Michigan Duck Hunters Association. The boxes were erected in February 1994.

10. Implementation

The project was initiated on February 28, 1994, completing the drainage ditch first, then installing

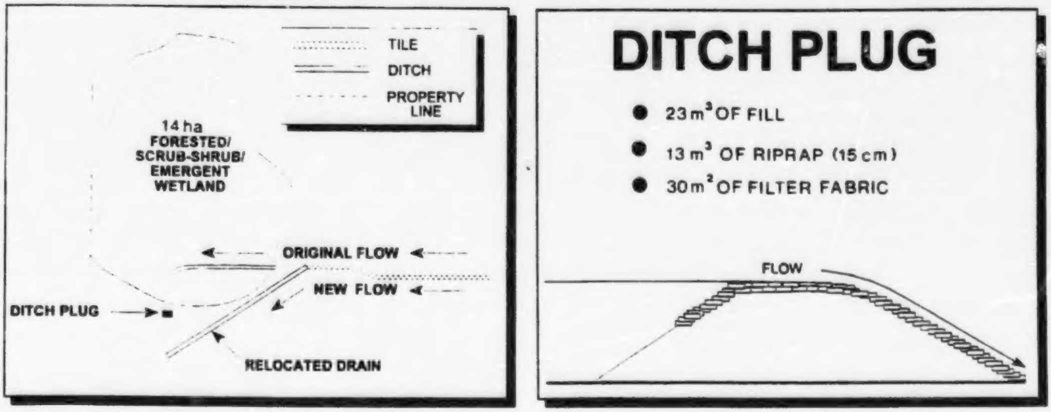
TILE
DITCH
PROPERTY LINE
14 ha FORESTED/ SCRUB-SHRUB/ EMERGENT WETLAND
ORIGINAL FLOW
NEW FLOW
DITCH PLUG
RELOCATED DRAIN
DITCH PLUG
23 m³ OF FILL
13 m³ OF RIPRAP (15 cm)
30 m² OF FILTER FABRIC
FLOW

Figure 1. Peterson wetland restoration project plan.

the ditch plug. The ditch plug consisted of 23 m³ of fill, 13 m³ of concrete rip-rap, and approximately 30 m³ of filter fabric. Earthmoving work was completed on March 7, 1994, except for leveling the spoil bank which was completed in April. Due to precipitation and warmer temperatures, site conditions became unfavourable after March 3, 1994, delaying the actual project completion by 1 month. The increased precipitation and temperatures did, however, fill the wetland to near capacity by March 10, 1994.

Two field drainage tiles were unexpectedly discovered while excavating the new ditch. Both tile lines were fitted with corrugated metal pipes, and rip-rap installed, to serve as inlets into the new ditch.

11. Degree of Environmental Intervention

Two tracked backhoes and a small dozer were used to complete the project. All materials, except for the filter fabric, corrugated metal pipe, and concrete rip-rap, were taken from the project site.

The drain relocation site was located in an agricultural field, as was the access route. Due to the installation date, the project was completed before any farming practices were instigated, allowing for minimal disruption.

12. Costs

Labor and materials	$6 200
Survey	$ 450
Inspection fees*	$ 500
Total	**$7 150**

* Clinton County Drain Commission

13. Biological Assessment

Expected results from the project consist of an increase in wetland vegetation and waterfowl use, water retention, water quality, and reduced siltation. Subsequent inspections verified wetland vegetation, waterfowl use, and water retention. Water quality and siltation data were not available due to inadequate monitoring and assessment.

An inspection on March 25, 1994 found the target water depths achieved. Approximately 80% of the wetland area had an average depth of 60 cm, while the remaining 20% ranged from 0 to 60 cm. More than 100 waterfowl were estimated to be using the wetland. Species documented include mallards, blue-winged teal, pintail, black duck, and wood duck. The ditch plug was functioning as designed and showed no signs of damage.

An area of the wetland previously farmed became open water when the wetland achieved the desired water elevation. An inspection on July 26, 1994 found excellent growth of emergent vegetation in this area. It was dominated by cattails and water plantain. Other species of wetland vegetation that were documented include duckweed, arrowhead, and blue flag.

Several wood ducks were observed feeding in an area of shallow water, although use of the wood duck nesting boxes was not documented.

An inspection on October 12, 1994 showed that the banks of the ditch have vegetation growing adequately but also have experienced some erosion. Parts of the ditch banks and leveled spoil bank have poor growth of vegetation due to the heavy clay soils exposed at these points.

14. Measures of Success

The Peterson wetland restoration project was deemed successful by the U.S. Fish and Wildlife Service and the Clinton County Drain Commission. Not only was a 14 ha wetland restored but agricultural drainage was maintained, possibly improved. The level of waterfowl use increased, not only for nesting, but for migration purposes. For water retention purposes, consider the following estimate:

80% of wetland averaging 0.6 m in depth = 11.2 ha
20% of wetland averaging 0.3 m in depth = 2.8 ha

11.2 × 0.6 ha · m = 6.7 ha · m
2.8 × 0.3 ha · m = 0.8 ha · m
Total 7.5 ha · m = 77 695 505 litres

Retaining more than an estimated 77.7 million litres of water out of the county drain was considered successful. This project provided excellent wildlife habitat in addition to reduced sedimentation, erosion, and flooding.

15. Key References

None.

Correct citation for this contribution:

Eitniear, T. 1995. Peterson Wetland Restoration Project, p. 282–286. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 46

1. Project Title: Paint Creek Habitat Improvement (Southeast Michigan)

2. Contact

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Mr. Ron Spitler
Michigan Department of Natural Resources, Southeast Michigan District Office, 38980 Seven Mile Road, Livonia, MI 48152, USA
Tel.: (313) 953-0241; FAX: (313) 953-0243

Mr. Dave Cozad
Mainstream Resources, 947 West Midland Rd., P.O. Box 96, Auburn, MT 48611, USA
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Mr. Allen Pienkowski
Clinton Valley Trout Unlimited, 830 Merton, #102, Detroit, MI 48203, USA
Tel.: (313) 341-1915

3. Agencies Involved

Michigan Department of Natural Resources
Local chapters of Trout Unlimited
Michigan Department of Corrections field crews

4. Restoration Goal

To enhance brown and brook trout stream habitat with wooden structures and to stabilize shorelines.

5. Project Type

Construction of "lunker" structures and other log structures; stabilize shorelines.

6. Background and Rationale

Paint Creek is one of the few trout streams in Southeast Michigan. Bank erosion problems were documented in a number of reaches of Paint Creek in Oakland County and local chapters of Trout Unlimited were interested in undertaking habitat enhancement and rehabilitation.

7. Regulatory Considerations

A permit was required under the Inland Lakes and Steams Act (Act 346).

8. Criteria

Stabilize eroding banks and enhance fish habitat.

9. Project Design

The project was designed to address some of the worst areas of erosion in Paint Creek that would also benefit from enhanced fishery habitat. "Lunker" structures are designed to simulate undercut banks and are most often installed on the outside bank in a stream meander (Figure 1). These structures typically provide 61 m of 15-30 cm deep cover simulating an overhanging bank. Because the area behind the structure is backfilled with rock, these structures can also be utilized to stabilize the toe of eroding banks in fairly stable streams. Paint Creek was scouring laterally into highly organic soils. Placement of the "lunker" structures served to stabilize the streambank, halt stream sedimentation, and provide cover for resident trout.

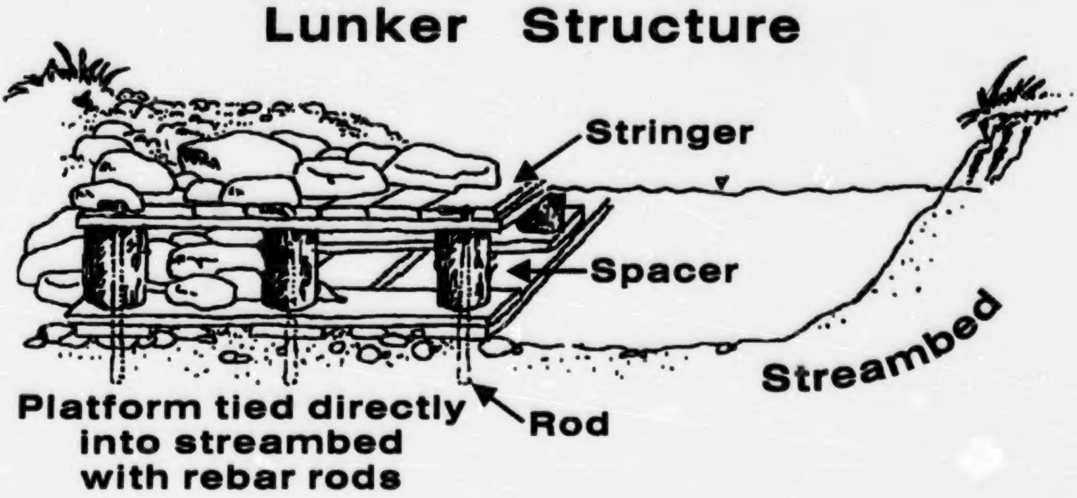

Figure 1.

10. Implementation

For a number of years, early 1980's and onward, local Trout Unlimited Chapters, co-ordinated by the Clinton Valley Chapter, have worked together in a 0.8 km stretch of Southeast Michigan's best trout stream (i.e., Paint Creek). Shoreline stabilization with rock, "lunker" structures and other log structures have enhanced that section of the stream.
"Lunker" structures are typically built in 2.4 m sections and range in width from 1.2 to 1.8 m. Most often the structures are constructed of 5 cm oak planking with 15-20 cm spacers. Six spacers are placed between the top and bottom decks of each structure and the section is then held in place by nine 1.5 m sections of 16 mm rebar. The structures are prefabricated in sections on land and then assembled streamside.

These "lunker" structures can be installed with two person crews and hand tools. Trout Unlimited volunteers and Michigan Department of Corrections crews installed approximately 53 m of lunker structure with 50 m³ of fieldstone backfill.

Professional planning is required to ensure that stream restoration efforts are truly meaningful and enduring.

11. Degree of Environmental Intervention

No adverse impacts were noted during lunker installation; however, original log structures (i.e., logs placed vertically at toe of bank to anchor other logs placed horizontally along bank) were pried loose by ice and high flow conditions, and resulted in log jams which had to be removed.

12. Materials and Cost

The following materials are required to construct one 2.4 m lunker section:

22 m of 5 × 15 cm rough sawn oak planking;
2.4 m of 10 × 35 cm oak;
90 cm of 15 cm diameter cedar post for spacers;
14 m of 16 mm rebar;
1.1 kg of 15 cm spikes; and
3 m³ of fieldstone rip-rap.
Approximate material cost per 2.4 m section was $115.00.

Approximately 0.5 person-days are required to fabricate and install one 2.4 m section, given reasonable stream access. As access becomes more difficult, installation costs will increase.

13. Biological Assessment

Fishery surveys are performed every 3-5 years on Paint Creek; however, these surveys do not allow for quantification of project effectiveness (evaluation of project effectiveness relative to the fishery would require a greater spatial and temporal sampling frequency; variability in urban steams is high).

14. Measures of Success

Success Rating: 4 – successfully installed a number of "lunker" structures which have resulted in bank stabilization, decreased erosion, and physical habitat enhancement.

15. Key References

Hunter, C.J. 1991. Better trout habitat: a guide to stream restoration and management. Montana Land Reliance (TSBN 0-93328078-5).

Correct citation for this contribution:

Thomas, M., Spitler, R., Cozad, D., and Pienkowski, A. 1995. Paint Creek habitat improvement (Southeast Michigan), p. 287–290. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.

Project 47

1. Project Title: Big Island Wetland, Sandusky Bay, Ohio

2. Contact

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3. Agencies Involved

Ohio Sea Grant College Program
City of Sandusky, Ohio
Ohio Department of Natural Resources (DNR)
U.S. Army Corps of Engineers
U.S. Fish and Wildlife Service

4. Restoration Goal

To compensate for the loss of 6.8 ha of wetland on the other side of Pipe Creek due to construction of the 44.5 ha condominium, hotel, restaurant, and marina complex known as "The Harbour"; to provide a site to store material dredged from a channel to the marina; to provide protection from erosion and wave attack for the City of Sandusky Water Treatment Plant.

5. Project Type

Construction of a diked wetland and rehabilitation of a wetland area to pre-1950 conditions.

6. Background and Rationale

The loss of wetland habitat on the south shore of Lake Erie has been significant. The only significant remaining wetlands in the Sandusky Bay area are diked and managed. Construction of a condominium/marina complex in the Sandusky area was being held up due to destruction of 6.8 ha of valuable natural wetland. Within 0.8 km of the site, a large wetland area had been destroyed by wave attack and the City of Sandusky's Water Treatment Plant was in danger. We developed a plan to mitigate the loss of 6.8 ha by diking and reconstructing a 38 ha wetland which would also protect the water treatment plant. The project included a management plan and a program of public education at the new wetland site (Figure 1).

7. Regulatory Considerations

Obtain a permit from the Army Corps of Engineers for dredging, filling and diking. It was also necessary to get design approval from the Ohio DNR and U.S. Fish and Wildlife Service for design specifications of the new wetland area to be sure it would provide habitat for fish, wildlife, birds, and a diversity of aquatic vegetation.

8. Criteria

It was essential that the water level in the new wetland be controllable, and to reduce maintenance costs, it was desirable to have gates on the exterior dikes to allow water to flow in and out by gravity if the gates were opened and closed at appropriate times when the water level in Lake Erie was changing. A 38 ha wetland would be difficult to manage experimentally; therefore, it was divided by internal dikes into four segments approximately 8 ha each. The water level in each segment had to be controlled independent of the other three. Dredged material could be placed into three segments in varying amounts, and a fourth segment would provide a borrow pit for dike

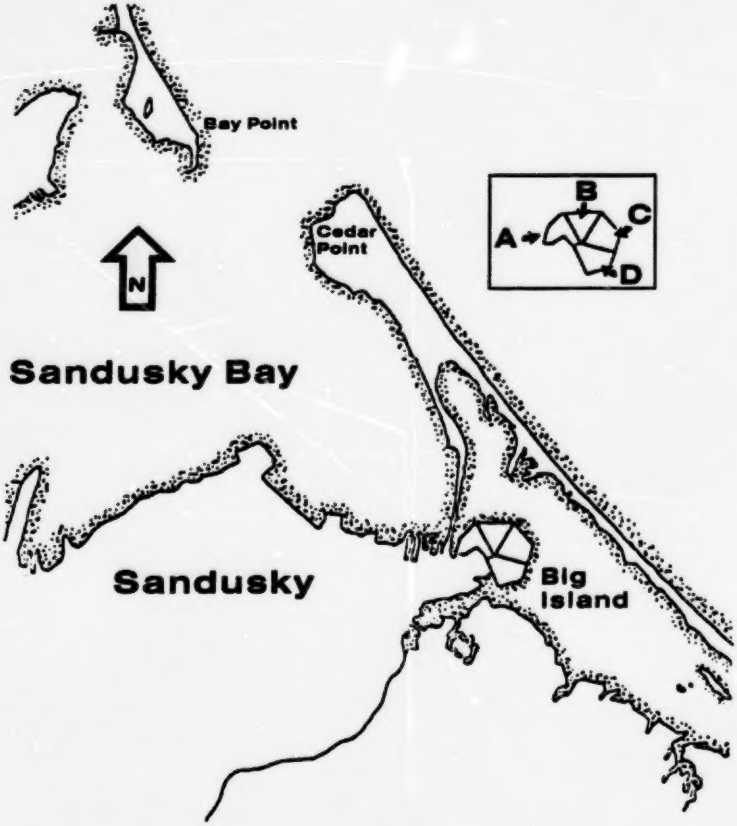

Figure 1. Insert shows location of the four cells within the wetland.

construction resulting in a variety of bottom elevations within the cells. This was necessary to develop a diverse flora and fauna.

9. Project Design

The wetland was to serve not only as an educational and experimental facility, and also as an asset to the region's ecosystem. We developed four experimental units within the wetland complex, each with its own water level control in order to run water in sequence from cell A to B to C to D, and then out, if desirable. It was also important to be control public access.

10. Implementation

Construction of the wetland was started in 1983 and was essentially completed by 1984. Original plans to seed the wetland with a variety of plant types proved unnecessary as natural vegetation in the seed bank took over immediately. The pumping system has been modified several times.

11. Degree of Environmental Intervention

Dikes were constructed into Sandusky Bay and a channel, approximately 30 m wide, was dredged resulting in the removal of several metres of sediment which was deposited in the wetland. The original plan to create islands with the dredged material was not successful, as the dredged material spread rapidly as it was pumped into the wetland cells in a slurry. However, it was possible to create varying bottom elevations which has required no maintenance and which has supported a diverse flora.

12. Cost

Various estimates range as high as $2.7 million.

13. Biological Assessment

Bald Eagles frequent the wetland for feeding and muskrats are numerous. Several students at Ohio State University have studied the flora as part of their thesis work (Siegley 1986). These studies have included determinations of the seed bank (Siegley et al. 1988). Additional graduate studies of the vegetation, insects, birds, and water quality are currently underway (contact Dr. Craig Davis, Ohio State University, School of Natural Resources). Duck hunters occasionally use the site in season.

14. Measures of Success

Bald Eagles frequent the site, a rare species of tern is nesting, muskrats are so numerous that they must be controlled to prevent defoliation; fishing from the dikes into the bay is excellent;

vegetation is diverse. Economic development on the other side has been diverse. In 1986, The Harbour (the developer and the name of the condominium complex) was presented the "Take Pride in America" award by the Ohio DNR for developing Lake Erie's foremost example of how public natural areas can be gained rather than lost during shoreline development. The Harbour was also a semifinalist for a similar national award from the U.S. Department of the Interior.

Success Rating: 5

15. Key References

Siegley, C.E. 1986. Analysis of the seed bank and early seral flora of big island wetland - a newly created freshwater marsh in Sandusky Bay, Ohio. Ohio State University. Ohio Sea Grant. OHSU-TD-014. 70p.

Siegley, C.E., Boernet, R.E.J., and Reutter, J.M. 1988. The role of the seed bank in the development of vegetation on a freshwater marsh and dredge spoil area. J. Great Lakes Res. 14(3): 267-276.

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Reutter, J.M. 1995. Big Island wetland, Sandusky Bay, Ohio, p. 291–294. *In* J.R.M. Kelso and J.H. Hartig [*editors*]. Methods of modifying habitat to benefit the Great Lakes ecosystem. CISTI (Can. Inst. Sci. Tech. Inf.) Occas. Pap. No. 1.